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WASHINGTON'S GREAT UNION STATION.*

By Frank N. Bauskett.

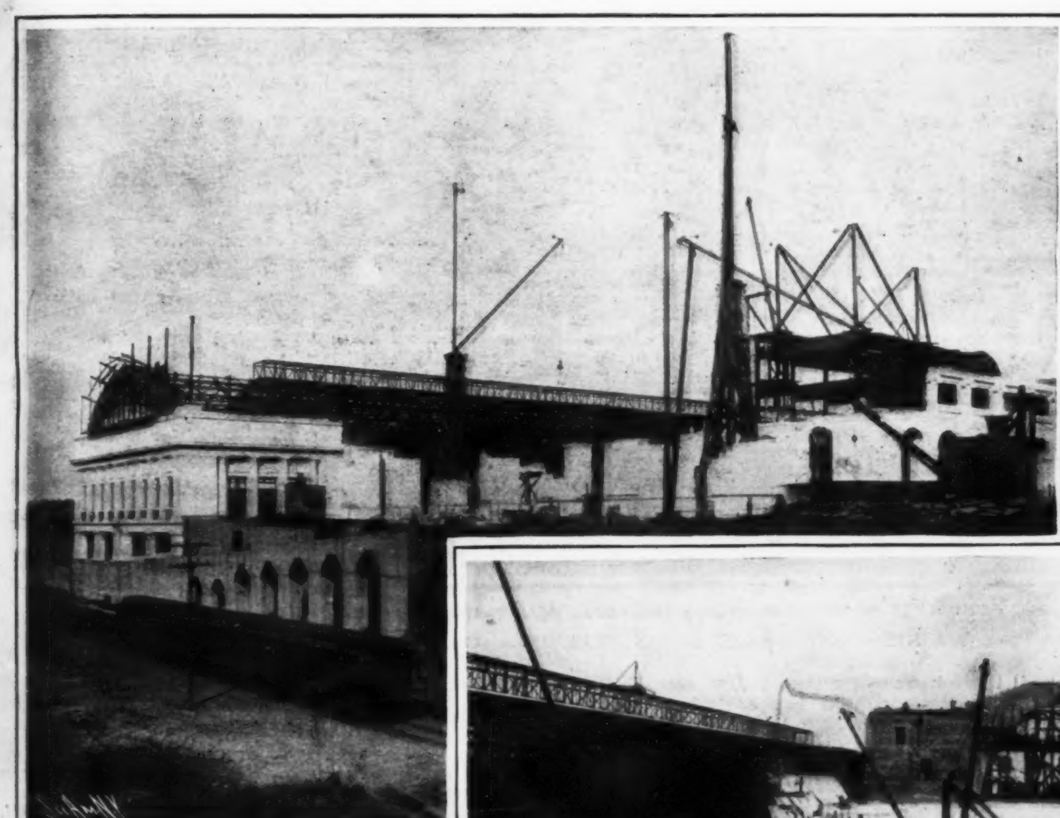
The great Union Station at Washington is nearing completion. There is probably no piece of work under way in America which excites more interest and curiosity than the construction of this vast Roman palace of shining white Bethel granite. Its central pavilion, modeled after the Arch of Constantine, and all its outlines preserving the central idea of a colossal city gate, is about thirteen feet longer and seventy-five feet wider than the United States Capitol. It will be the finest example on record of a conscious and costly co-operation on the part of railroad companies in an attempt to beautify a great city.

To insure the building its full effect a semi-circular plaza 1,200 by 650 feet has been created in front of it, with avenues radiating to half the points of the compass. Through the center of these avenues the visitor, emerging from the main door of the station, sees the vista of the Capitol, the most imposing and appropriate of all possible introductions to the nation's seat of government.

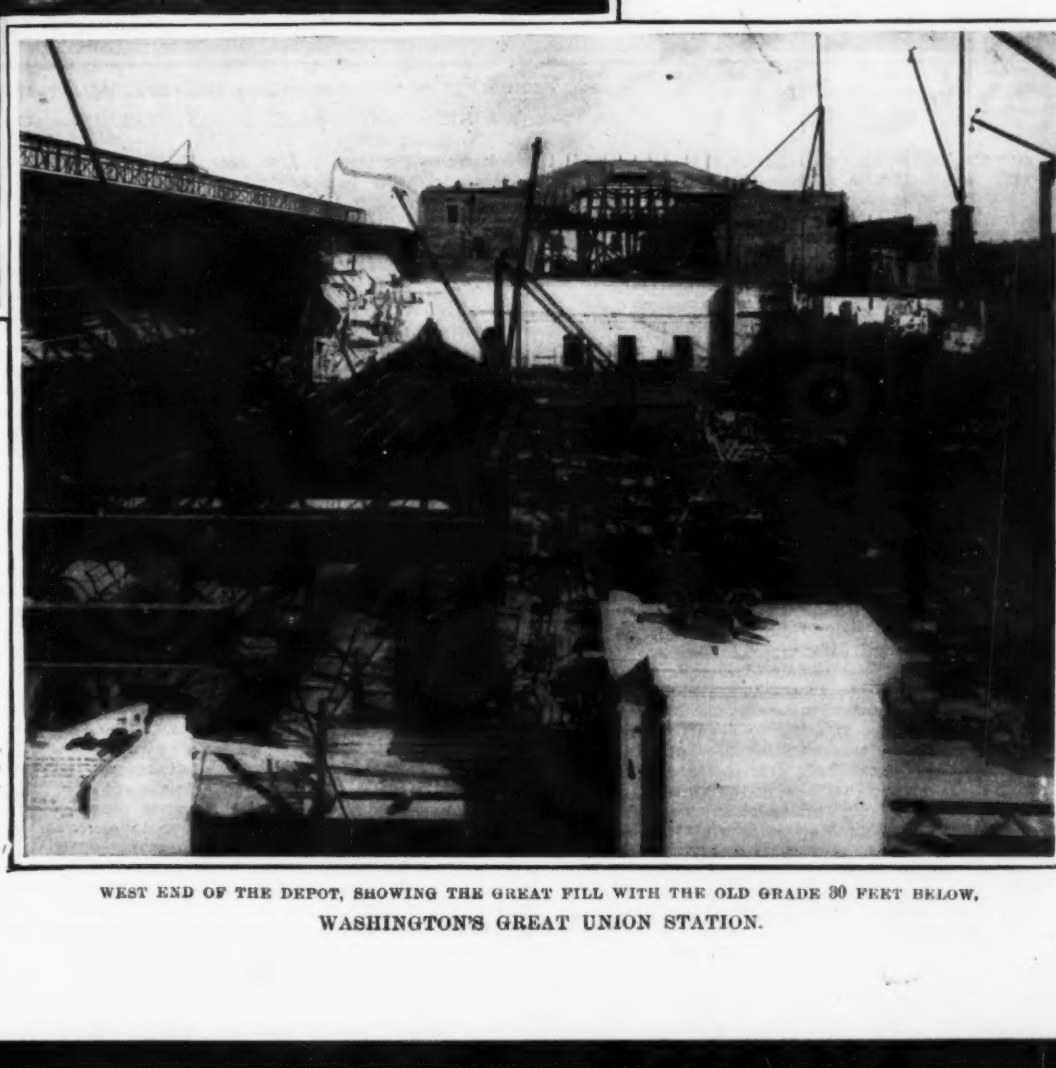
The main building alone will cost $5,000,000, while nearly $15,000,000 will be spent in grading and the erection of approaches which circumstances and the demand of beauty require should be done. It is estimated by the engineers in charge of the work that it will be completed by next July, provided, of course, that the winter at Washington is not an unusually severe one, which would necessarily delay the progress of the structure. The new terminal will occupy the vast space of 165 acres. To simplify and minimize the number of construction problems which, of necessity, would have to be met with on a work of this magnitude, the entire layout was divided into three separate divisions: the terminal depot building, the north approach, and the south approach. To avoid controversy and confusion with the operating departments of the Baltimore & Ohio Railroad and Pennsylvania Railroad, upon whose respective territories much of the work had to be done, the construction of the north approach and the depot building was assigned to the Baltimore & Ohio Company, while the south approach and its connections was assigned to the Pennsylvania Company.

There are several points of especial interest in connection with this construction, viz., the construction of two tunnels, side by side, separated by a dividing wall but four feet in thickness. The work on one tunnel, embracing a side wall and the middle wall with connecting arch, was carried on somewhat in advance of the other, after the custom of building single tunnels. The construction of the other side wall with its connecting arch then followed, completing the two-track tunnel. In the work on these tunnels an enormous amount of timber was used in supporting the over lying material. The crown bar system of timbering was first employed in the removal of the earth from the space in which the arch was to be erected. Segmental timbers were then placed inside the crown bars to strengthen the work. The completed tunnels will have, outside of the masonry, timbers aggregating about two feet in thickness. This two-track tunnel is nearly a mile in length.

The shovel used in excavating the mass of the material removed in building the tunnels was operated by compressed air, by the use of which all smoke and gases were avoided, allowing the workmen to perform their labor under the most favorable conditions without adding materially to the cost of construction. The quantity of material entering into such a piece of work and the excavated material moved from one portion of the space to another are necessarily large. The filling, for example, amounts to about 900,000 cubic yards—enough to cover an acre lot of ground to a depth of over 550 feet. To fill the plaza and raise adjacent streets to the new grade, about 1,000,000 cubic yards of material is required. When it is considered that an ordinary cart has a capacity of less than a cubic yard, some conception of this volume may perhaps be had, as it would require over 1,000,000 carts each carrying a load to remove the dirt. If this material were deposited on an average-sized city block, the sides being kept vertical, it would form a shaft about 460 feet in height. If all the material which will be moved to prepare the site for the coach, engine, and shop yards, about 2,500,000 cubic yards, were similarly deposited, it would cover a city block to the depth of 600 feet, or sufficient to cover the Washington Monument. To excavate this material would require the services of a steam shovel moving an average of 30,000 cubic yards a month from ten months to a year, taking into consideration natural delays. If this material were moved on standard gage commercial cars, such as are used for hauling coal, it would require 80,000 cars to carry it off. And if these cars were coupled together in a single line, they would cover a distance of 600 miles. Large figures are not only applicable to the material used and moved, but to the finished work as well. The head house



THE MAIN WAITING ROOM, NOW ONLY A JUMBLE OF CONSTRUCTION MATERIAL.



WEST END OF THE DEPOT, SHOWING THE GREAT FILL WITH THE OLD GRADE 30 FEET BELOW.

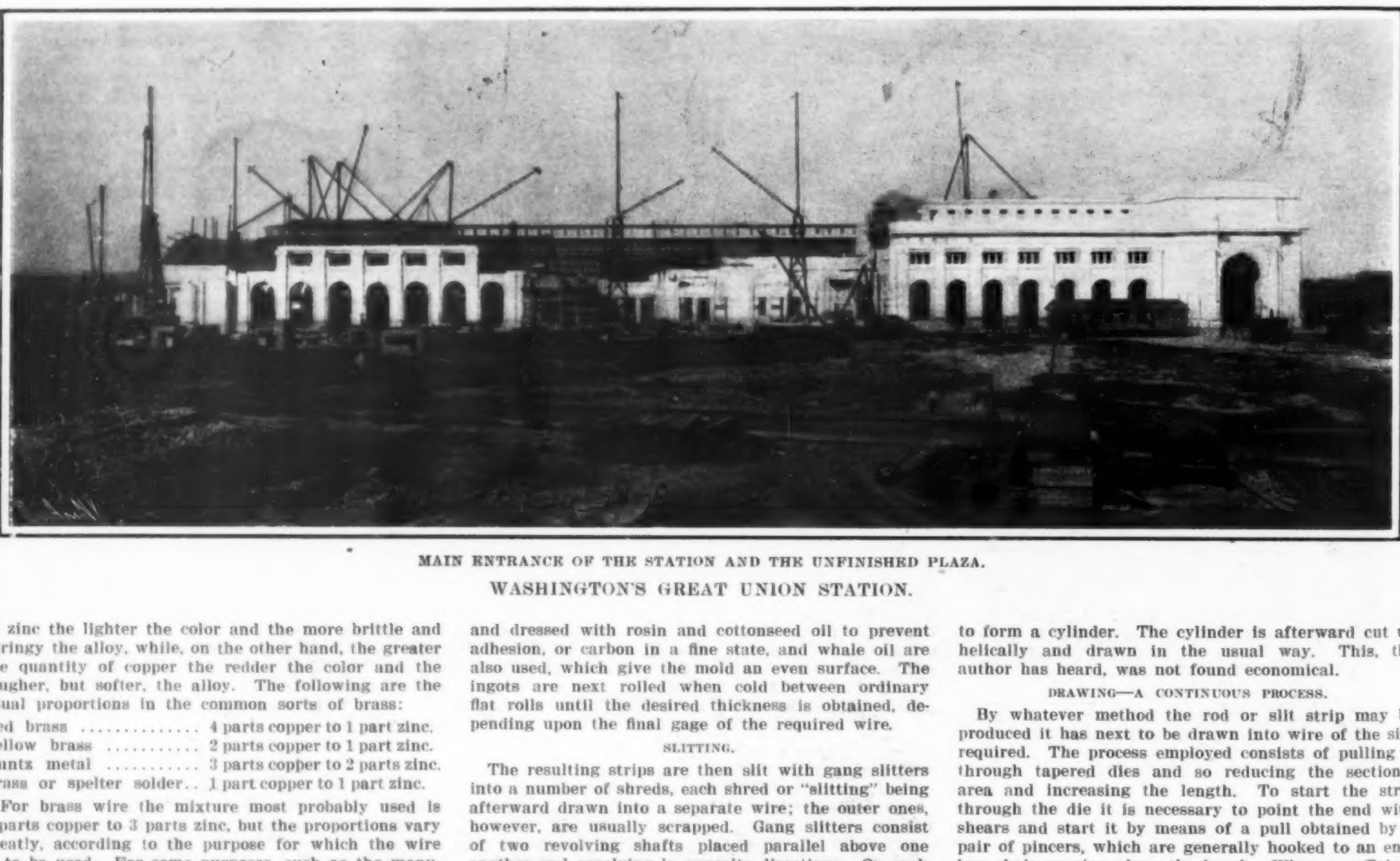
WASHINGTON'S GREAT UNION STATION.

* Specially prepared for the Scientific American Supplement.

alone, 220 by 625 feet, covers 140,000 square feet, while the concourse covers 130 by 760 feet. The general waiting room is 130 by 220 feet, and is in itself larger than the average city depot. In addition to this immense room there are the usual other rooms found in an up-to-date railway station.

The transportation of the various materials entering into a work of this magnitude is a greater problem than might at first be considered. There has been delivered approximately the following: Fireproofing material, 245 cars; stone ballast and screenings, 11,300 cars; sand, 3,500 cars; cement, 1,400 cars; cinders, 5,500 cars; brick, 1,800 cars; structural steel for building, 385 cars; structural steel for bridges and girders, 350 cars; granite, 450 cars; new rail, 215 cars; old rail, 70 cars; frogs and switches, 110 cars; track fastenings, 100 cars; limeoid, 60 cars; terra cotta conduit, 30 cars; terra cotta pipe, 11 cars; cross ties, 530 cars; water-proofing materials, 34 cars; contractors' plant, 176 cars; coal, 860 cars; lumber, 600 cars; cast-iron pipe, 76 cars; signal bridges, 6 cars; bumping posts, 3 cars; making nearly 30,000 carloads of material.

The concrete foundations of the depot building, owing to the elevation of the structure above the street level, are forty-five feet in depth. The material for filling-in has all been delivered and the work is progressing rapidly. When this filling-in is completed, the level will be thirty-five feet above the original surface of the ground in the vicinity. The granite and brickwork of the east end of the building is nearing completion, but the steelwork in this structure, being nearly all wall-bearing, can only be placed as the progress of the masonry permits.



MAIN ENTRANCE OF THE STATION AND THE UNFINISHED PLAZA.

WASHINGTON'S GREAT UNION STATION.

THE MANUFACTURE OF BRASS WIRE.*

By E. J. BOLTON.

THE quality of brass depends upon the proportions of the two constituents—i. e., the greater the quantity of zinc the lighter the color and the more brittle and springy the alloy, while, on the other hand, the greater the quantity of copper the redder the color and the tougher, but softer, the alloy. The following are the usual proportions in the common sorts of brass:

Red brass	4 parts copper to 1 part zinc.
Yellow brass	2 parts copper to 1 part zinc.
Muntz metal	3 parts copper to 2 parts zinc.
Brass or spelter solder	1 part copper to 1 part zinc.

For brass wire the mixture most probably used is 5 parts copper to 3 parts zinc, but the proportions vary greatly, according to the purpose for which the wire is to be used. For some purposes, such as the manufacture of pins, where rigidity is of more importance than toughness and cheapness is essential, it is possible to use Muntz metal, while for drawing into very fine gages and weaving into the gauze that is used largely in paper making machinery much richer grades are employed. As zinc is a much cheaper metal than copper the more zinc used the cheaper the brass.

The three important operations in the manufacture of brass wire from copper ingots and spelter are casting, rolling (and in some cases slitting), and drawing.

CASTING.

The alloying of the copper and spelter is performed in crucibles. These are generally made of plumbago and are about 16 inches in depth and 10 inches in diameter at the top, tapering to about 9 inches in diameter at the bottom, the thickness of the walls being about 1 inch. These crucibles are heated in furnaces, the common type being the "wind furnace." This is fired with solid fuel and has a natural draft, the height of the chimney stacks varying from 40 feet, where each furnace has its separate stack, to 150 feet, where a number of furnaces are connected to one stack. It is usual to heat a number of crucibles at once, each in a separate grate connected to a main flue, which leads the products of combustion to the stack. Gas furnaces are also used in combination with generators, in which case producer gas, or sometimes water gas, is burned in place of the solid fuel; in these it is usual to heat ten or twelve crucibles in one furnace or chamber. Reverberatory and tilting furnaces are employed for large castings in sand molds, but for casting ingots in metal molds it is usual to employ a crucible furnace of the "wind furnace" type, the fuel commonly used being coke. Tilting furnaces are especially used in America.

ROLLING.

Most of the grades of brass can only be rolled cold, and in consequence the same methods are not available as in the manufacture of copper and steel wire. Muntz metal is the only mixture that can readily be rolled hot satisfactorily, and it is possible to roll wire rods of small diameters of this metal, as is done with copper. The process is difficult, owing to the narrow range of temperature at which the metal is workable. It is, the author has been informed, done to some extent in America.

The oldest method of making brass and the one still very largely used is as follows: The metal is cast into long, narrow ingots of about 1 hundredweight each, or a little more, and from 3 to 4 inches wide. The molds are generally made of cast iron, cast in halves, which are clamped together with wrought iron rings. The molds are placed below the surface of the floor of the casting shop, and are supported against the side of the pit at an angle of about 60 degrees. Boards are placed across for the caster to stand upon while pouring the metal from the crucible into the mold. The metal, after careful skimming, is poured into the mold at the top, and when it has set the rings are slipped off the mold and the upper half removed, leaving the casting or ingot exposed. Before the metal is poured into the mold the inside of the mold is well brushed and dressed with rosin and cottonseed oil to prevent adhesion, or carbon in a fine state, and whale oil are also used, which give the mold an even surface. The ingots are next rolled when cold between ordinary flat rolls until the desired thickness is obtained, depending upon the final gage of the required wire.

SLITTING.

The resulting strips are then slit with gang slitters into a number of shreds, each shred or "slitting" being afterward drawn into a separate wire; the outer ones, however, are usually scrapped. Gang slitters consist of two revolving shafts placed parallel above one another and revolving in opposite directions. On each shaft is mounted and keyed a row of circular steel plates of a thickness equal to the width of the intended slittings, and kept equal distances apart by collars of the same thickness. The edges of the cutting rings are turned absolutely square and the sides true. The rings on one shaft fit into the grooves on the other, and slit the strip in much the same way as scissors cut cloth. The strip when once started works its way through the cutters, owing to the opposite direction of revolution of the two cutters.

The advantage of this system is that it is cheap and the strip can be made suitable for any required size of wire without much subsequent drawing. The disadvantage is that, if the strips are slit into narrow shreds in order to save drawing, owing to the ingot being limited in weight by considerations of convenience in handling, only light pieces of wire are obtained, the weight of the piece depending upon the width of the slitting. These light pieces are not liked by consumers, and also entail much labor in drawing. If the slittings are heavy they are large in section, and therefore require a great deal of drawing. This may, however, be got over to a certain extent by rolling the strip comparatively thin and subsequently rolling the slitting again in an edgeways position into an approximately circular section, much less in diameter than its original width. Probably the best process, and the one employed almost universally in America, at any rate for grades of brass which can only be rolled cold, consists of casting the brass in the form of long bars, either square or round, from 1¼ to 1½ inch thick. Each of these bars is rolled down separately in the cold state into a rod about ⅜ inch in diameter, or sometimes less, which is afterward drawn into wire. Pieces weighing from 60 to 70 pounds can thus be obtained. The advantage of this process over the old one is that longer lengths are obtained and labor in the drawing is to some extent saved.

A process brought out some years ago in the North of England consisted in casting in a centrifugal mold about 18 inches in diameter, and mounted on a vertical axis revolving at a high speed, so as to produce a casting in the form of a hoop. This was rolled down in open ended rolls, brought together with hydraulic pressure, and working in the same manner as those used for rolling out the tires for locomotives and other railroad rolling stock. A large, thin hoop about 3 inches wide resulted, which was then cut in circular shears helically, forming a long strip, and this was drawn in the usual way. The great advantage of this method lay in the fact that a heavy piece was obtained, at the same time having a small section ready for drawing. This process appeared full of promise at the time, but has not been heard of since, very probably owing to the fact that the critical temperature in the cooling was reached while the metal was in motion, thus spoiling the homogeneity of the alloy and possibly causing distortion of the molecular structure, the quality and strength of the metal being therefore reduced. In France a method often employed of making the "slittings" is to roll the metal down into large sheets, which are cut into strips spirally. This method is all right, but, so far as the author is aware, it has not been adopted in England. Another method tried in America consists in casting a solid billet, which is pierced with a suitably constructed mandrel to form a cylinder. The cylinder is afterward cut up helically and drawn in the usual way. This, the author has heard, was not found economical.

DRAWING—A CONTINUOUS PROCESS.

By whatever method the rod or slit strip may be produced it has next to be drawn into wire of the size required. The process employed consists of pulling it through tapered dies and so reducing the sectional area and increasing the length. To start the strip through the die it is necessary to point the end with shears and start it by means of a pull obtained by a pair of pincers, which are generally hooked to an endless chain moving along the bench. When a sufficient length has been pulled through the die to reach the wire block the end is attached by a small vise to the latter, which consists ordinarily of a slightly conical drum mounted on a vertical spindle and flanged at the lower end. The wire is wound on this in a continuous coil, constantly slipping up the slightly inclined surface. The power being applied to this drum the force required to draw the wire through the die must be transmitted entirely by the wire itself, and consequently the limit to reduction at one draft is reached when the force required to pull the wire through the die is nearly equal to the maximum tensile stress that the resulting wire can stand without rupture.

In recent years continuous drawing machines have come very much into use. With these machines, instead of winding the wire on a block, after drawing through one die at a time, the wire is drawn through one die, then wound two or three times around a block and taken through another die, and so on, the friction on each drum being sufficient to carry the wire forward and the circumferential speed of the drums being varied to suit the elongation of the wire. Owing, however, to brass being very quickly hardened by drawing it is not possible to carry on this process *ad infinitum*, unless the wire be annealed periodically. When once it has been annealed it is

* From a paper read before the Graduates' Section of the Institution of Mechanical Engineers (Great Britain).

possible to effect a very large reduction at one draft, the actual amount varying with the composition of the brass, the larger the proportion of copper the greater the reduction at one draft. It is obvious, therefore, that the labor saved on continuous machines is much less in the case of brass than it is in the case of a metal like copper, which can be drawn through many dies in succession without annealing. The author has seen fine copper wire passing through as many as twenty diamond dies on one machine. In any case, however, continuous machines are of little use, unless the pieces of wire are fairly heavy.

DIES.

In England steel dies are chiefly used, which are set to size by the wire drawer with a punch of the correct diameter and shape. In America chilled cast iron is used, and these dies are reamed out to size by a special man, who spends all his time looking after them, the wire drawer merely attending to the machine. In both countries for fine wire diamond dies are utilized. These dies are formed with a rough diamond set in a suitable metal holder, through which a hole of the required diameter is drilled and through which the wire passes from one block to another. Diamond dies are practically always employed in connection with continuous machines up to gages where the size would be so large as to make the price prohibitive. The reason for using diamonds is, of course, that they are harder than steel; they therefore last longer than the steel or chilled cast iron dies, and very seldom require adjusting to size. The foreman of the die department of a Birmingham firm recently showed the author a diamond die which he said had been in constant use for the last seven years, whereas steel dies require resetting constantly. The manufacture of these dies forms in these days an industry in itself, but one or two of the most important British firms manufacture their own dies. The holes in the diamonds are drilled by means of hard steel drills pressed lightly against the stone, while the latter is revolved at a very high speed and fed with oil and diamond dust. Wire as fine as 0.001 inch is obtained in this way, which is considerably finer than a human hair, the usual diameter of which varies from 0.0025 to 0.003 inch. It can readily be imagined that the drilling of holes 0.001 inch in diameter through a diamond is a very delicate process requiring much care and skill. The author believes the manufacture of diamond dies originated in Switzerland.

INTERIOR VIEW OF THE CONCOURSE, SHOWING THE 130-FOOT SPAN OF THE STEEL ROOF.

WASHINGTON'S GREAT UNION STATION.

RADIUM AND GEOLOGICAL CHANGES: BERTHELOT'S EXPERIMENTS.

PROF. BERTHELOT published on October 6, 1906, some results of experiments which tend to rehabilitate theories long since abandoned and to furnish a fresh proof that science moves in circles.

The amethyst is known to consist almost entirely of silica and to owe its violet color which distinguishes it from the rhinestone and the ordinary quartz crystal, to a quantity of oxide of manganese too small to be estimated by chemical analysis. More than thirty years ago Jannettaz discovered that the color of the amethyst is destroyed by heat. Berthelot repeated this experiment with the same result. Amethysts, heated in an open test tube to about 300 deg. C. (570 deg. F.), remained transparent but lost their color completely and to all appearance permanently, for they did not regain a trace of it after two months' exposure to the air, and exposure to bright sunlight for seventy hours.

The color was restored, however, by the prolonged action of radium. About one-third of a grain of radium chloride was placed in a little glass bulb. This was sealed with the blowpipe and placed in a tube of thicker glass which was also sealed, wrapped in several thicknesses of filter paper and introduced into the test tube containing the blanched amethysts. The test tube was then, on August 22, shut up in a dark closet. Three weeks later, on September 15, the amethysts were found to have acquired a faint violet tinge, which had become much deeper on October 6, the date of Prof. Berthelot's writing.

Now the color of the amethyst is unquestionably due to a compound of a higher oxide of manganese, as is shown by the ordinary laboratory test of the presence of manganese in minerals. A little of the mineral is added to a bead of fused borax on a loop of platinum wire and the bead is heated in the oxidizing flame of the blowpipe. If manganese is present the bead assumes the violet tint of the amethyst, but loses its color on being reheated in the reducing flame. These changes of color can be repeated indefinitely by subjecting the bead alternately to the oxidizing and the reducing flame. In this case the coloring is evidently caused by oxidation and the blanching by deoxidation.

So Prof. Berthelot regards the blanching of amethysts on being heated as a result of deoxidation, the oxygen being simply expelled through the interstices between the layers of which the crystal is composed, and which are revealed in some specimens by striated coloration, or even through the apparently homogeneous mass of the laminæ themselves. Similar movements of gaseous or other matter through a solid occur in the cementation process for making steel, and in the phenomena of occlusion. In the amethyst the inverse process, the return of the oxygen from without and its recombination with the deoxidized manganese residue, appears to take place only under the influence of the rays emitted by radium.

Nor is the amethyst the only substance so affected. One of the tubes of quartz-glass, or fused quartz, which are now articles of commerce, had remained perfectly colorless during a year of exposure to diffused light although the quartz contained a trace of manganese. This quartz tube was placed in the test tube beside the sealed radium tube and kept in darkness. In a few weeks a violet band appeared in the quartz tube opposite the radium and the color has been growing deeper for months.

Prof. Berthelot has obtained very interesting results with fluor spar. In the first place he proved that violet fluor spar, like amethyst, loses its color on being heated. He heated in a test tube a piece of fluor spar from Durhamshire until it was completely and permanently blanched. Then he subjected it to the influence of radium in the manner already described. A faint rose tint appeared in twenty days, and the color has since been increasing in intensity, though more slowly than the color of amethysts similarly treated.

Smoky quartz from the Tyrol, blue corundum or sapphire, and red corundum or ruby were also blanched by heating but their colors have not yet been restored by the action of radium. Rubies and sapphires, however, owe their colors not to manganese but to chromium.

Prof. Berthelot says: "The results obtained with quartz and fluor spar give a possible explanation of the violet coloration of natural specimens of those minerals which have been formed in darkness and particularly of the color of amethysts formed in geodes. The color may be attributed to radiations that traverse bodies opaque to light." He adds: "These experiments give evidence of radioactive effects, resembling those of the electric effluvium, which have played a part hitherto unsuspected in the coloration of precious stones. They recall the theories of Aristotle and the alchemists and the rôle which subterranean exhalations were formerly supposed to play in the production of ores and even of metals."

Rosnel's "Mercure Indien," published in 1672, contains the following curious passage: "The ruby is produced gradually in the mine. It is white at first and turns red as it ripens, for which reason some rubies are pure white and others are half white and half red."

An extra-terrestrial origin was ascribed to the effluvia which caused geological changes and each metal was supposed to be produced by the influence of a particular planet, silver by the moon, gold by the sun, iron by Mars, copper by Venus, mercury by Mercury, tin by Jupiter, and lead by Saturn. The power of the planets was likewise extended to gems: that of Saturn to the turquoise, Mars to the emerald, Venus to the amethyst, the moon to quartz, Mercury to the lodestone, the sun to the diamond, and Jupiter to the carnelian.

The actual growth of certain minerals, such as stalactites, was proved by observation, and the Digest of Roman laws made by order of Justinian contained regulations governing the title to stone re-formed in exhausted quarries. Here we find a hint of the geological views which have recently come into favor under the generic title of activism. The fundamental idea is that the matter which composes every geological deposit is continually undergoing changes caused by internal attractions and the liquids which percolate through it so that the minerals which compose a stratum may be of much later formation than the stratum itself.

These views are now generally accepted although, twenty years ago, rocks were regarded as permanent and unchangeable. A writer in a scientific journal of 1890, in discussing the exploded and extravagant conjectures of the past, adduces as a striking example the following passage from Bernard Palissy (1563): "The earth is never idle. Everything that is consumed in it is promptly renewed in one form or another. As the surface of the earth is always laboring and bringing forth, so is the interior."

The writer of 1890 adds, in allusion to the "Mercure Indien" quoted above: "A century later (1672) it was still thought that nature is never idle," etc.

So it is thought to-day, though it was not in 1890, and the quotation from Palissy would be an appropriate motto for an activist geological treatise. Prof. Berthelot's experiments gave a striking suggestion of the eternal circulation of matter and energy in the depths of the earth.—Condensed from Stanislas Meunier in La Science au XXme Siècle, December 14, 1906.

EXPORTS OF MANUFACTURES FROM THE UNITED STATES IN 1906.

EXPORTS of manufactures from the United States in the year just ended aggregated more than 700 million dollars. The Bureau of Statistics of the Department of Commerce and Labor has completed the figures for the eleven months ending with November, and adding to these a conservative estimate for December finds that the total exports of manufactures for the full year will, beyond question, exceed 700 million dollars. Ten years ago, in the fiscal year 1896, they amounted to but 258 millions; in 1886, but 145 millions, and in 1876, 105 millions. The share which manufactures formed of the total exports was, in 1906, 42 per cent; in 1896, but 30 per cent; in 1886, but 22 per cent, and in 1876, 20 per cent. Thus the exports of manufactures in 1906 are three and one-half times as great as a decade ago, and the share which manufactures form of the total exports about one-third greater than at that time.

This is the first time that exports of manufactures have crossed or even approximated the 700 million dollar line. Even in the fiscal year 1906, which is only six months away, the total exports of manufactures were but 686 millions; in 1905, 612 millions; in 1904, 523 millions; in 1903, 468 millions; in 1902, 454 millions; in 1901, 466 millions; in 1900, 484 millions; in 1899, 380 millions, and in 1898, 325 millions. Thus the exports of manufactures in the calendar year 1906 are actually twice as great in value as in the fiscal year 1898, having thus doubled in eight years.

Practically one-half of the manufactures exported from the United States goes to Europe, the great manufacturing section of the world. Of the 686 million dollars' worth of manufactures exported in the fiscal year 1906, 318 million dollars' worth went to Europe, 182 millions to North America, 79 millions to Asia, 64 millions to South America, 30 millions to Oceania, and 13 millions to Africa. Of the 318 million dollars' worth of manufactures sent to Europe, 73 millions was manufactures of copper, 46 millions mineral oil, 44 millions manufactures of iron and steel, 32 millions manufactures of wood, 27 millions leather and manufactures thereof, 16 millions naval stores, 13 millions agricultural implements, and the remainder miscellaneous manufactures. Of the 182 million dollars' worth of manufactures sent to the various countries of North America, 72 millions was iron and steel manufactures, 18 millions wood manufactures, 10 millions cotton goods, 8 millions leather and manufactures thereof, and 7½ millions cars and carriages.

The United States now holds third rank among nations as an exporter of manufactures. The total exports of manufactures from the United Kingdom in the latest year for which statistics are available were 1,333 million dollars; from Germany, 910 millions; from the United States, 700 millions; from France, 661 millions; from Netherlands, 347 millions; from Austria-Hungary, 215 millions; from Belgium, 204 millions; from Italy, 200 millions; from Switzerland, 141 millions, and from Russia, 117 millions. It will thus be seen that in this grouping of the world's great exporters of manufactures the United States now stands third in the list, though it is proper to add that the figures for the United States are for the calendar year 1906, while those for practically all the other nations quoted are for the year 1905.

Manufactures form, however, a much larger percentage of the exports of the great manufacturing countries of Europe than they do of the exports of the United States. The share which manufactures form of the exports of the United Kingdom is 83 per cent; Switzerland, 76 per cent; France, 70 per cent; Germany, 67 per cent; Italy, 60 per cent, and of the

United States, as above indicated, 43 per cent in the calendar year just ended.

The value of manufactures now entering the world's international commerce now aggregates about 5 billion dollars, and the United States thus supplies nearly 15 per cent of that total.

PRODUCER GAS POWER TEST.*

DATA OBTAINED AT THE PLANT OF THE GOULD COUPLER COMPANY, DEPEW, N. Y.

By J. R. BIBBINS.

GAS producers, especially for bituminous fuels, are quite familiar in metallurgical work, notably in the various iron and steel industries. Although the prob-

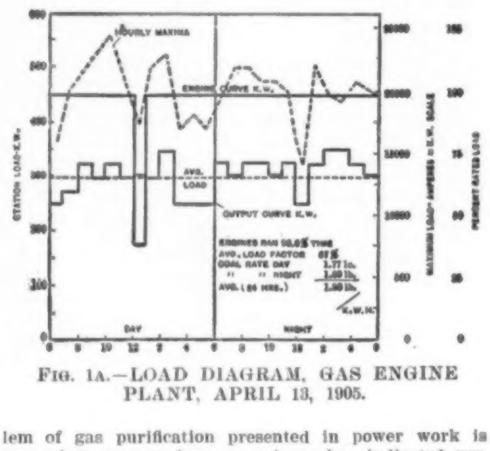


FIG. 1A.—LOAD DIAGRAM, GAS ENGINE PLANT, APRIL 13, 1905.

lem of gas purification presented in power work is somewhat more serious, experience has indicated several fairly simple methods of solution. The ability of the modern gas engine to take the place of the steam engine in general power work has likewise been questioned, as well as the ability of the gas-engine and producer to work together harmoniously under widely varying load demands.

Fortunately neither of these charges is founded on a basis of actual conclusive experience, and it is the purpose of this paper to present some practical data upon the operation of a thoroughly representative commercial gas power plant, one in which a high measure of success has been obtained through intelligent engineering and supervision. Even though some minor improvements might still be suggested, the fact remains that this gas power plant is operating week in and week out, 24 hours per day, 6½ days per week, on a fluctuating manufacturing load, with a fuel consumption fully one-half that of a modern steam plant of like character and suited to the same work. On an average of half load this 450-kilowatt plant ordinarily consumes from 2 to 2¼ pounds of coal per kilowatt-hour, and on heavier loads has reached as low a consumption as ½ pound per kilowatt-hour in regular daily running. During heavy loads the plant has repeatedly developed without the battery 530 kilowatts on maximum fluctuations, which represents an overload of 18 per cent rating. Furthermore, with the exception of the engineers in charge during the two watches, the plant is operated by attendants originally quite unskilled in gas work. Up to the present writing, however, no complete interruption of service traceable to defective equipment has been recorded.

SERVICE AND DETAILS OF PLANT.

These facts are thought to be sufficiently impressive to warrant their presentation to the society, particularly as this plant may be regarded as exemplifying modern engineering practice and the service resulting therefrom. The plant in question serves the entire Gould manufacturing properties at Depew, a suburb

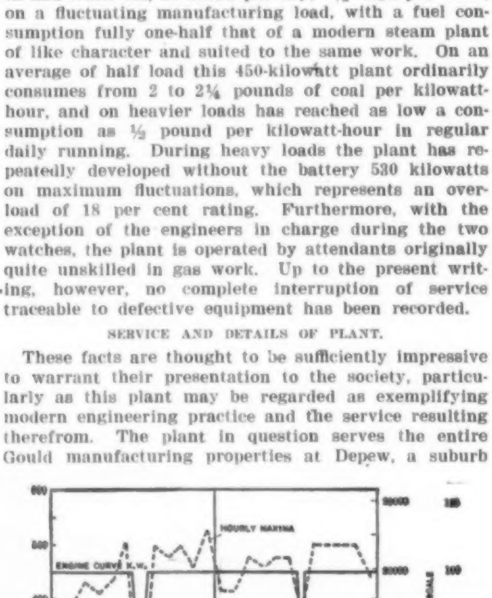


FIG. 1B.—LOAD DIAGRAM, GAS ENGINE PLANT, JULY 11, 1905.

of Buffalo, N. Y. Two complete works are located here: One devoted to the manufacture of storage batteries and the other to the manufacture of railroad specialties, principally automatic couplers. The latter contains a large and well equipped steel foundry. Both are electrically driven and lighted throughout from the central gas power plant. Contributing to the station load are a large number of labor-saving machines of different types, such as electric traveling cranes, charging tables, transfer locomotives, elevators, conveyors, fans, pumps and machine shop tools. The storage battery works also use considerable current at times for "forming" battery plates.

Table I.—Equipment Data, 450-kilowatt Producer Gas Engine Power Plant.

Service—Power, some lighting.
Number of units—Three, 150 kw.
Distribution system—D. C. two wire.
Pressure—250 volts, normal 230.
Power building—45 x 61 ft. inside.
Height of roof trusses—28½ ft.
Height of basement—9 ft.
Total area per kilowatt—6.1 sq. ft.
Net area of unit—15 x 33½ ft.
Engines—Westinghouse three-cylinder, vertical gas engines, single acting four-cycle.
Capacity—235 b.h.p., 260 maximum.
Normal speed—200 rev. per min.
Size cylinders (3)—19 x 22 in. stroke.
Ignition—110 volts and 8 volts. 2 sets four cells storage battery.
1 motor generator set, ½ kw.
Cooling water (jackets)—Motor driven centrifugal pumps. (With 6-ft. passageways.)
Net area unit per kilowatt—2.87 sq. ft.
Walls—Red brick, exterior pilasters, limestone trimmings, steel framework.
Roof—Wood, tar and gravel, steel trusses, monitor.
Floors—Steel, wood, ¾-in. maple finish.
Basement floor—Concrete.
Foundation—Concrete.
Crane—Hand power.
Producer building—Steel framework.
Corrugated iron walls and roof.
Charging floor—Boiler plate.
Cooling pond—1,000,000 gals.
Dimensions—280 ft. diam. x 93 ft. wide.

	Sq. ft.
Area (power plant)...	7,300
Area (producer plant)	7,500
Total	14,800

Depth—Normal 10 ft.
Holder—36 in. diam., single lift, 15,000 cu. ft.
Coal used—Bituminous run of mine.
Sources—Buffalo, Rochester & Pittsburg Railroad.
Price—$2.30 per ton.
Heat value—13,500 B.t.u.
Two 2-in. Worthington "volute." 15-hp. motor, 1450 rev. per min.
Cooling water (scrubber)—Two-stage motor driven. 2-in. Worthington "turbine" type. 15-hp. motor.
Compressed air—100 lb. from works, also 6 x 6 in. Rand duplex single stage compressor. 10-hp. motor.
Generators—Westinghouse compound wound, D. C.
Capacity—150 kw., 250 volts.
Switchboard—250 volt D. C.
Producers—Loomis-Pettibone.
Type—Bituminous, duplex intermittent blast, 3 ft. to 8 ft. diam.
Boiler—5 ft. diam. vertical tubular, utilizing waste heat.
Wet scrubber—6 ft. diam., vertical, coke, water sprays.
Dry scrubbers—Two 9½ ft. diam., in parallel; excelsior, two layers.
Valves—Gear lift, water cooled.
Exhauster, Root's—Simple engine drive.
Gas main—12 in. diam.
Gas risers to engine—8 in.
Fittings—Screwed.
Valves—Chapman gate.
Coal handling—Bucket elevator, motor driven.

FLUCTUATIONS IN LOAD.

Although the power station load is smoothed out to some extent by the overlapping of demands from these various sources, yet the larger machines pull heavily upon the system, with the result that the load at the

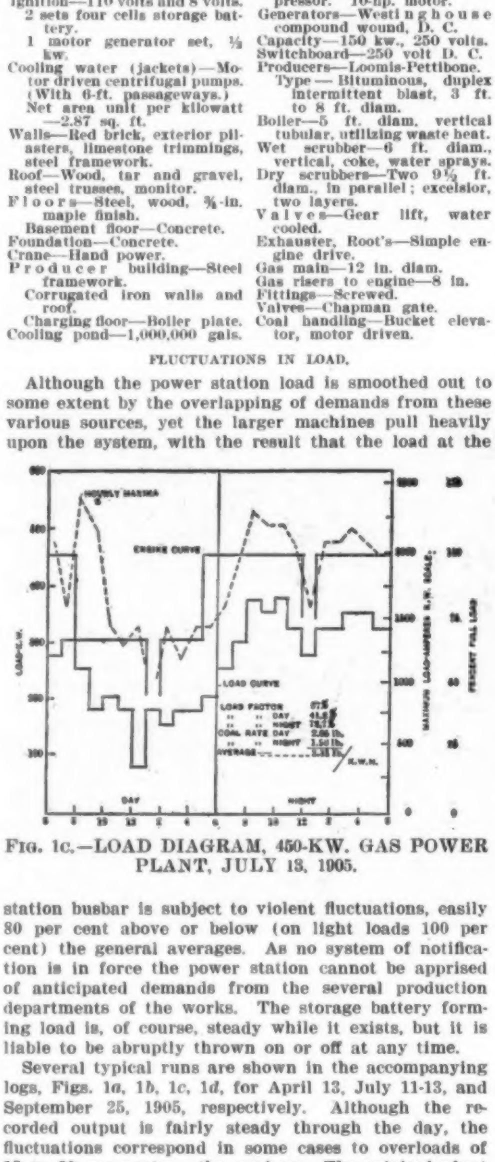


FIG. 1C.—LOAD DIAGRAM, 450-KW. GAS POWER PLANT, JULY 13, 1905.

station busbar is subject to violent fluctuations, easily 80 per cent above or below (on light loads 100 per cent) the general averages. As no system of notification is in force the power station cannot be apprised of anticipated demands from the several production departments of the works. The storage battery forming load is, of course, steady while it exists, but it is liable to be abruptly thrown on or off at any time.

Several typical runs are shown in the accompanying logs, Figs. 1a, 1b, 1c, 1d, for April 13, July 11-13, and September 25, 1905, respectively. Although the recorded output is fairly steady through the day, the fluctuations correspond in some cases to overloads of 15 to 20 per cent on the engines. The original plant was entirely capable of handling these fluctuations, but on account of doubling the steel plant load and adding electrically driven air compressors, an auxiliary storage battery was recently installed for the dual purpose of securing a more constant load on the engines with higher economy of fuel, and of increasing the average load. Formerly it was necessary to keep the spare unit constantly in service to tide over the peaks. This storage battery, however, was not placed immediately in service, and does not affect the results presented in this paper except in the matter of capital costs.

PLANT DUTY.

From the daily records of the plant an excellent idea of its operative efficiency may be obtained. These records, although not elaborate, are carefully kept and show not only the output and duty of the plant but also the maximum loads that occur during the hour. A digest of a typical day's run is given in Table 2 and shows continuous operation except at noon and midnight—to be exact, 97 per cent of the elapsed time. The load averages 263 kilowatts, or 58 per cent of the generating capacity in service with nine full load hourly maxima and five equivalent to 8 per cent overload. The average coal consumption for all purposes was 1.89 pounds per kilowatt-hour generated.

During a 10-day run in September, 1905, the results shown in Table 3 were recorded. The engines averaged 87¼ per cent of the possible running time, and on 54 per cent station loading factor the plant consumed 2.04 pounds fuel per kilowatt-hour, or 1.44 pounds per brake horse-power hour. The loading factor = average 24-hour station load ÷ rated capacity. The true load factor = average 24-hour load ÷ maximum. With coal of 13,500 B. T. U. calorific value the efficiency of this plant averages about 13.1 per cent, thus rivaling, if not excelling, the largest modern steam power stations. On September 27, the fuel rate was 1.88 pound per kilowatt-hour (or about 1¼ pound per B. H. P. hour) with 62 per cent loading factor, corresponding to a plant efficiency of over 15 per cent.

The author has been deeply interested in the effect of the loading factor of a plant upon its efficiency and commercial duty. An unusually good opportunity arose in analyzing the results of this plant and the approximate relation is presented in Fig. 2. In order to obtain a closer average, the "shotgun" method (Fig.

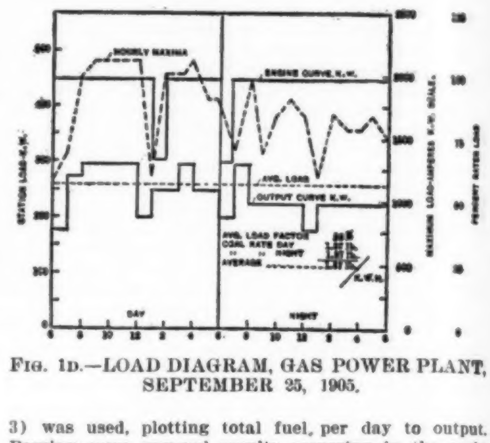


FIG. 1D.—LOAD DIAGRAM, GAS POWER PLANT, SEPTEMBER 25, 1905.

3) was used, plotting total fuel per day to output. Barring some unusual results occurring in the early days of the plant, the average fuel consumption is approximately a straight line within observed limits. From this the average fuel per kilowatt-hour may be obtained, Fig. 4, and the relation approximates a rectangular hyperbola within normal ranges of load. The upper convex curve, Fig. 4, expresses the kinetic or absolute efficiency of the station. Kinetic efficiency is defined as = thermal equivalent of work done ÷ heat in coal. It is interesting to observe that this small plant normally operates with an efficiency between 12 and 13 per cent average. Since the observations above referred to were made the plant has been giving much better efficiency, the coal consumption averaging 1.8 per kilowatt-hour with an 85 per cent loading factor. This corresponds to the plant efficiency of over 15.4 per cent at the engine shaft, or 14 per cent at the switchboard. Several runs averaging 1.55 pound per kilowatt are recorded, equivalent to a plant efficiency of 17.7 per cent at the shaft, of 16.3 per cent at the switchboard.

Table II.—Typical Log.

Gas Power House Daily Statement for September 26, 1905.

Time.		Producers in 1	2	3	Engines in 1	2	3	Pumps in 1	2	3	Station Watt-Meters. Output. K W	Volts.	Max. amperes.	Remarks.
A. M.	7	Δ	Δ		Δ	Δ	Δ	Δ	Δ	Δ	1,459,900	230	1000	8% overload.
	8										,300	230	2100	
	9										,300	230	2100	
	10										,300	230	2000	
	11										,300	230	2100	
	12				∇	∇					,300	230	2100	
P. M.	1				Δ	Δ					,100	230	2000	
	2										,300	230	2100	
	3										,300	230	2000	
	4										,300	230	2000	
	5										,300	230	2000	Full load about 1950 amperes.
	6										,290	230	1800	
	7										,250	230	1700	
	8										,300	230	1900	
	9										,300	230	1900	
	10										,300	230	1800	
	11										,300	230	1900	
	12					∇					,300	230	1900	
A. M.	1										,150	230	1100	
	2					Δ					,300	230	1900	
	3										,350	230	1800	
	4										,300	230	1800	
	5										,300	230	1900	
	6	∇	∇		∇	∇	∇	∇	∇	∇	,350	230	1700	

Meter Readings.

6 p.m.	1,462,600	6 a.m.	1,466,000
Previous	1,459,700	Previous	1,462,600
Output	2,900	Output	3,400
Coal, 6,000; coke, ——.		Coal, 6,300; coke, ——	
Rate, 2.06 lb. per kw.hr.		Rate, 1.85 lb. per kw.hr.	

Table III.—Operating Data.

Date. Sept. 1905.	Engine hours' run.	Per ct. full day run.	Output, kw. hr.	Load—Kw. Aver.	Load—Kw. Rated.	Station loading factor.*	Fuel used.	Coal per kw. hr.	Coal per b.h.p. hr.
20	71	98¾	4,850	202	450	45	11,100	2.29	...
21	65½	91	5,275	220	450	49	11,400	2.16	...
22	70	97¼	6,550	273	450	61	12,700	1.93	...
23	45¾	63½	4,025	188	450	41.7	8,800	2.18	...
24 Sun.	24	33⅓	2,250	187.5	450	41.6	†6,600	†2.93	...
25	70½	98	6,400	267	450	59	12,000	1.87	...
26	69¾	97	6,300	263	450	58	12,300	1.95	...
27	70½	98	6,700	279	450	62	12,600	1.88	...
28	72	100	6,700	279	450	62	12,900	1.92	...
29	70½	98	6,600	275	450	61	12,900	1.95	...
Aver.	63	87¼	5,565	243.4	450	54	11,330	2.04	1.44

* Loading factor = % continuous generating capacity.
† Includes extra coke used on Sunday for starting new fires.

EFFICIENCY OF THE PRODUCER.

From the above data and the measured efficiency of the gas engine, the efficiency of the producer plant may be roughly estimated. Assuming 50 per cent loading factor, the average plant efficiency is 12 per cent. As the efficiency of the engines is approximately 17 per cent at this load (see Fig. 6), the producer plant operates at an efficiency of slightly above 70 per cent.

* A paper read at the New York meeting of the American Society of Mechanical Engineers.

With higher loading factor, 75 per cent, the plant efficiency is 13 per cent average, engines 20 per cent and producers 65 per cent. During an especially good day's run, as on September 27, the efficiencies were as follows: plant 15 per cent, engines 21 per cent, producers 71.5 per cent. These results indicate that the producer plant is, from an everyday operative standpoint, fully as efficient as a high-grade boiler plant and frequently more so. It is certainly not more difficult to handle.

COST OF POWER.

As to the cost of power the following analysis reveals a total cost of well under 1 cent per kilowatt-hour, including fixed as well as operating charges. At normal prices, coal costs $2.30 per ton. Assuming an average daily output of 5,000 to 10,000 kilowatt-hours, representing the probable minimum and maximum for full working days, and adding the fixed or capital charges amounting to about 9 per cent on $91,650 (or $81,000 excluding the battery), the distribution of cost items is substantially that given below:

Approximate Power Costs.

	Minimum.	Normal.	Maximum.
Output—Kw.hr. per day	5,000	8,000	10,000
Fuel—Cents per kw.hr.	0.25	0.22	0.20
Labor—Cents per kw.hr.	0.28	0.17	0.14
Supplies and repairs (estimated), —Cents per kw.hr.	0.17	0.13	0.11
Operating costs—Cents per kw.hr.	0.70	0.52	0.45
Fixed charges	0.45	0.28	0.22
Total costs—Cents per kw.hr.	1.15	0.80	0.67

The charges for supplies and repairs in the above are estimated, owing to absence of more accurate data and the comparatively short time plant has been in operation. Assume 25 per cent of total power costs at 50 per cent L. F., hence the estimate is conservative. It should be noted that were the plant to operate regularly at the lower load factors less labor and supplies would be required and the light load costs would be correspondingly reduced. The curves, Fig. 5, are based on full plant in service operating continuously.

In order to emphasize the effect of the loading factor, Fig. 5 has been prepared showing the relation of both capital and operating costs to the station loading factor, the former plotted above and the latter below the X axis. Total cost of power is given by the total ordinate. Observe the rapid change in costs on light loading, especially of fixed charges. Coal, on the other hand, remains fairly constant; labor, a constant

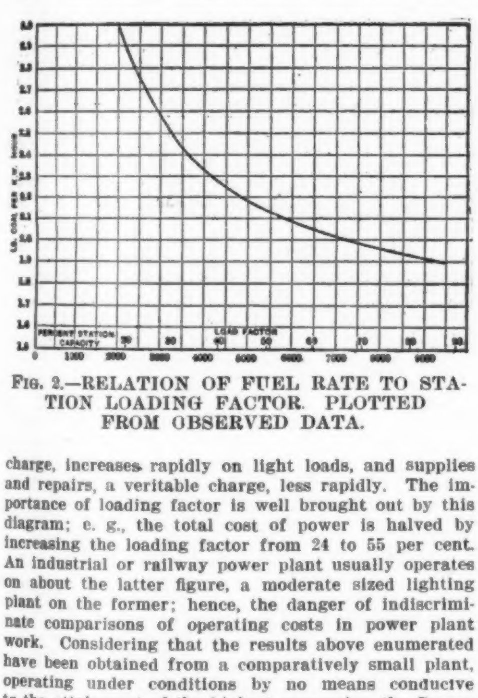


FIG. 2.—RELATION OF FUEL RATE TO STATION LOADING FACTOR. PLOTTED FROM OBSERVED DATA.

charge, increases rapidly on light loads, and supplies and repairs, a veritable charge, less rapidly. The importance of loading factor is well brought out by this diagram; e. g., the total cost of power is halved by increasing the loading factor from 24 to 55 per cent. An industrial or railway power plant usually operates on about the latter figure, a moderate sized lighting plant on the former; hence, the danger of indiscriminate comparisons of operating costs in power plant work. Considering that the results above enumerated have been obtained from a comparatively small plant, operating under conditions by no means conducive to the attainment of the highest economies, the Depew plant offers a striking object lesson that should not fail of appreciation among engineers confronted with similar problems.

GENERATING PLANT.

Considerations of operating economy largely influenced the choice of gas engines for this plant where steam coal costs from $2.25 to $2.40 per ton, and gas coal about the same. At this price it was estimated that, although the difference between the steam and gas was small on half-day working, for a 24-hour day

Table IV. Average of Engine Efficiency Tests.

Load.	Over.	Full.	Half.	Remarks.
Brake horsepower	325.3	239	121.3	By Prony brake
Speed rev. per min.	198	203	206.3	By counter.
Gas per hour	3,547	2,840	1,985	Corrected to 62° F., 30" Hg.
Gas per b.h.p.hr.	10.9	11.87	16.36	Corrected gas—no load—1,250 ft. per hour.
Heat value gas*	920	920	920	Effective B.t.u. per cu. ft.
B.t.u. per b.h.p.hr.	10,030	10,910	15,050	
Brake kinetic efficiency	25.37	23.32	16.9	B.hp. basis.
Mechanical efficiency	89	87.5	82.5	Estimated.
Indicated kinetic efficiency	28.5	26.7	20.5	I.hp. basis.
Speed variation-max.	4.2%			No load speed, 206.6.
Speed variation, no-full load		1.8%		Average speed.
Speed variation, no-half load			0.7%	
Per cent. full rating	138.4%	101.6%	51.6%	On producer gas.

* Pittsburgh natural gas—Junker calorimeter.
Engines rated 235 b.h.p. on 130 B.t.u. producer gas.

the latter's advantage was decisive. The installation of three units of similar size and identical construction wisely avoided the duplication of parts which two or three sizes of engines would have occasioned. By the use of direct connected units a very compact power house arrangement has resulted, the total floor area per kilowatt being 6.1 square feet, and the net area of each unit with 6-foot passageways 2.9 square feet per kilowatt.

The efficiency of these engines as heat engines is

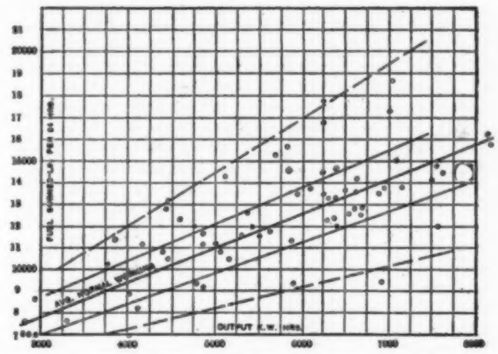


FIG. 3.—FUEL CONSUMPTION OF VARIOUS OUTPUTS. GRAPHICAL METHOD OF OBTAINING TRUE AVERAGE.

well indicated by the appended results of tests shown in the accompanying Table 4 and diagram, Fig. 6, made at the builder's works on natural gas which was at that time the only fuel available for testing purposes. As engines for producer gas are usually constructed for somewhat higher compression than those operating on illuminating or natural gas, their efficiency would presumably be slightly better on natural than on producer gas fuel; yet for commercial work a difference of 15 pounds in compression would scarcely be appreciable. In Fig. 6 the upper concave curve represents the gas consumption per B. H. P. under different loads, and the convex curve, the kinetic or absolute efficiency.

The ability to convert into useful power over 25 per cent of the effective heat in the gas gives evidence of high efficiency.

These engines operate on the four stroke cycle involving constant quality of mixture and throttling governing. The actual proportioning of gas and air is accomplished by two plug valves at the bottom and the top of the mixing chamber, respectively, each with graduated index. These valves may be set by hand at any time to accommodate varying qualities of gas. An automatic diaphragm pressure regulator reduces the pressure of the incoming gas to atmosphere at the engine.

ENGINE AUXILIARIES.

A most important factor in the successful operation of the engines is the ignition apparatus. For increased security each igniter plug has two sets of points, each set independently connected. Should one set of points, through any cause, become unfit for use, a small double throw switch may be reversed, thus turning the ignition current through the other points. In addition, three independent sources of current have been provided, all of the apparatus being contained in a central ignition cabinet. For starting, one of two 8-volt storage batteries is used. For running, a small ½-kilowatt motor generator unit is used delivering 110-volt current to the igniters through incandescent lamps, which furnish a valuable "tell-tale" for "open circuits," "grounded igniters," or "hanging fire" of igniters. These two sets of storage batteries are charged alternately through a bank of lamps from the motor generator or from the main station bus bar, one or the other set being always available in an emergency. By means of small double pole switches at the igniter

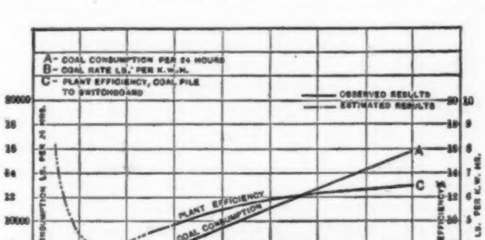


FIG. 4.—AVERAGE PLANT DUTY AT VARIOUS LOADING FACTORS.

cabinets, throwing over from the low to the high tension system may be instantly accomplished without in the least disturbing the engines. The ignition problem has thus been handled with great care in the provision of six individual combinations of current supply.

Starting of the engines is accomplished as usual by compressed air drawn from a pipe connection to a compressed air line in the works or from the relay compressor. Although only 90 to 100 pounds pressure is ordinarily carried, yet the engines may readily be brought up, cold, to full running speed, within 30 to 40 seconds. With higher air pressure available, starting may be accomplished in even less time, as the mixture ignites more readily when quickly compressed,

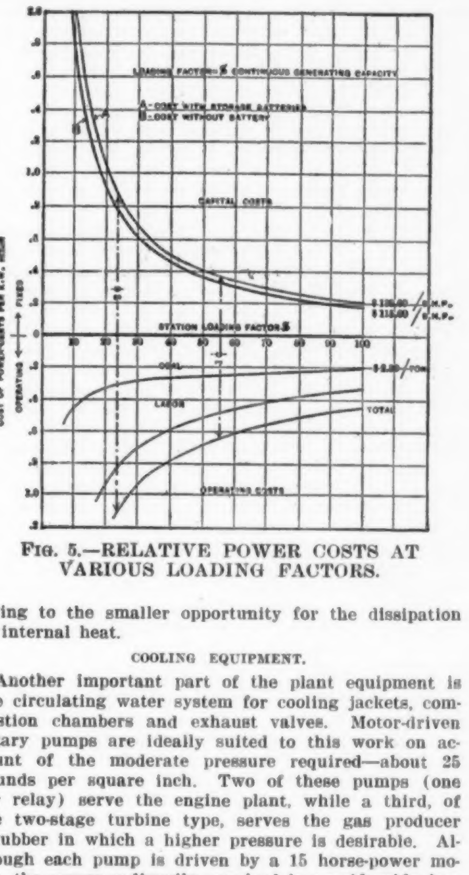


FIG. 5.—RELATIVE POWER COSTS AT VARIOUS LOADING FACTORS.

owing to the smaller opportunity for the dissipation of internal heat.

COOLING EQUIPMENT.

Another important part of the plant equipment is the circulating water system for cooling jackets, combustion chambers and exhaust valves. Motor-driven rotary pumps are ideally suited to this work on account of the moderate pressure required—about 25 pounds per square inch. Two of these pumps (one for relay) serve the engine plant, while a third, of the two-stage turbine type, serves the gas producer scrubber in which a higher pressure is desirable. Although each pump is driven by a 15 horse-power motor, the power ordinarily required is considerably less than this, especially in moderate and cold weather when the quantity of water supplied to the engines may be largely reduced by throttling the pump outlets.

Cooling water for the engine is drawn from near the bottom of the cooling reservoir through a screen house, while the hot jacket water is returned to the surface of the pond, about 150 feet distant. During the progress of the water from inlet to outlet enough heat is dissipated to the earth and atmosphere to reduce the outlet water to the proper temperature. During periods of extreme heat and humidity when the cooling process is retarded, a larger quantity of water may be sent through the jackets to compensate for the lesser difference in temperature. For this the rotary pumps are well suited. In September, 1905, the following observations were made:

	Deg. F.
Jacket water entering pond	99.3
Surface of water near inlet	78.8
Air	73.8
Bottom of reservoir near outlet	76.1
Surface of reservoir near outlet	77.9
Average load on plant	310 kw. = 500 h.p.

Thus on a fair day with practically seven-tenths load on the plant there was a difference in temperature of 1.8 deg. F. in eight feet depth of water, 0.9 deg. F. difference between the temperature of reservoir at intake and outlet, 4.6 deg. F. difference between air and mean reservoir temperature and 23.2 deg. F. total cooling. Apparently considerable cooling took place through the transmission of heat through the bottom of the reservoir.

PIPING.

Some trouble has been experienced with the gas

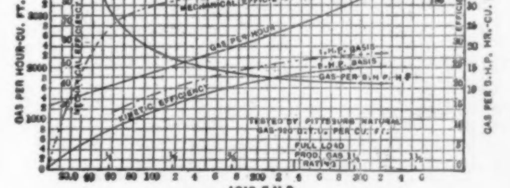


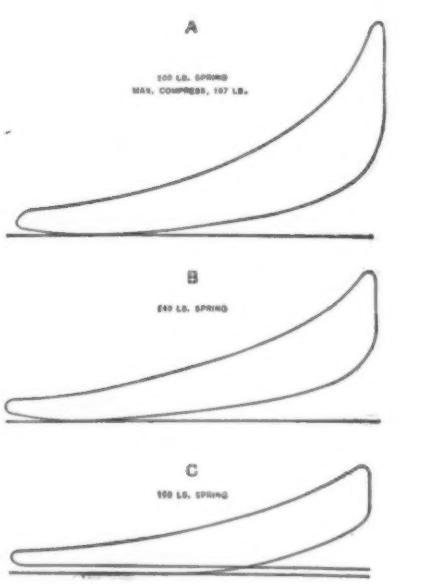
FIG. 6.—AVERAGE EFFICIENCY TESTS OF THREE 19 x 22 INCH SINGLE-ACTING GAS ENGINES, FOUR-CYCLE TYPE, VERTICAL.

gates, due apparently to cumulative deposits of carbon, and frequently it becomes impossible to seat the valves tight. In work of this class it would seem that a parallel seated, quick closing gate would be best suited, being self-cleaning, and the gas could be cut off almost instantly in case of emergency.

The engine exhausts all discharges into a cast iron header running beneath the floor to a concrete exhaust well outside, serving as a muffler. Unfortunately, it is impossible to cool these exhausts by water sprays on

account of the large amount of SO_2 in the gas. If water were used, as is the practice with natural gas, the piping would soon be destroyed by corrosion. As some 30 per cent of the total heat value of the gas is lost in the exhaust, radiation is a somewhat disagreeable feature, especially in warm weather. This trouble may, however, be obviated by inclosing the piping in a concentric sheet metal casing through which rapid circulation may be maintained from basement to ventilators in the roof. It is also possible that a reinforced concrete duct might be employed for exhaust piping, molded in sections, cemented in position and incased in sheet steel. If rigidly supported this material should easily withstand both the heat and corrosive action of the exhaust vapors when water is cooled in the usual manner.

The muffler well is, to be sure, a common arrangement in gas power plants, but most certainly could be improved upon. First, the noxious products of combustion rising from the pit, although located in the open, are driven directly into the engine room during certain prevailing winds to the great discomfort of the operators. Second, if the exhaust pit is carried to any considerable distance from the power house, a serious back pressure is imposed on the engines owing to the friction of the high pressure exhausts on the internal surface of the main. Usually the well is located close to the building with a short standpipe. This outlet is almost invariably too small, resulting again in serious back pressure from throttling. And it usually occurs that sooner or later the structure is dismantled by sudden pressures due to delayed combustion or other causes. A more logical arrangement would seem to be as follows: (1) A brick or concrete exhaust well of large dimensions built next to the power house foundation wall and loosely filled with large broken rock, (2) a brick stack extending to the



FIGS. 7A, 7B, AND 7C.—TYPICAL INDICATOR CARDS, CORRESPONDING TO LOADS IN TABLE IV.

roof and built into the building structure integral with pilasters, thus taking advantage of the reinforcement offered by the steel skeleton of the building, (3) simple sheet steel flap doors or louvres inserted in the roof of the exhaust pit and at two or three points in the chimney to relieve occasional local pressures. In this manner the noxious gases are easily taken care of by a flue of cheap construction, agreeable appearance, and ample capacity for any contingency.

COOLING WATER PIPING.

The piping for cooling water is simple, a manifold supplying all three cylinder jackets in parallel. Water enters at the bottom of the jacket, emerging from the top. A small pipe loop at the discharge end of the upper manifold with vent cock at the top to break the vacuum serves to prevent the syphoning effect which under certain conditions might pull all the water out of the jackets, leaving nothing but steam. This vent is useful as a tell-tale showing stoppage of jacket water supply.

In cooling the exhaust valves a fairly constant supply is desirable, irrespective of the load. The arrangement shown in Fig. 8 is therefore employed, by which the jacket water may be throttled as much as desirable, while constant head is maintained at the exhaust valves.

OPERATION OF ENGINES.

Four men, two to a shift, operate the generating plant, the oilers and the two engineers, being formerly steam engine operators. The personal attitude of the chief engineer toward the gas engine plant well refutes the frequent argument that gas engines require more skilled operators than steam engines. The plant not only requires less actual manual labor to keep in running order, but it is fully as responsive to good handling as a steam plant. All things considered, he "would regret to go back to steam." The fact that the engines are often left in charge of, and operated by, the oilers illustrates the point in view.

While the producer is undergoing renovation on Sundays, the engines are also inspected in rotation, mixing valves flushed down with gasoline to remove lampblack deposits (likewise cylinders, now and then to keep the packing rings free), valves are ground in and igniters replaced when necessary, jacket deposits cleaned out when obstructed to any extent, and the engines generally adjusted. Reducing valves are also cleaned at intervals from carbon deposits. Practically the only trouble experienced thus far has been the occasional cutting of an exhaust valve, presumably due to cumulative carbon deposits on the valve seats. The lampblack has also occasioned some difficulty in lubricating valve stems. Igniters, of course, wear down gradually, but extras are always kept on hand and repointed as fast as necessary. Usually one igniter will last from six to nine months without repointing. Since commencing normal operation engine repairs have been confined to these two items and are comparatively light considering the conditions of operation. Very little trouble has been experienced with lubrication, as the main working parts are automatically supplied by the splashing of oil. All oil used in outer bearings returns to the crank case to make up that lost through evaporation. When the oil reaches too high a level the excess is drawn off, filtered and used over in the bearings.

In starting and stopping the engines the attendants have acquired so much skill that the barring lever is seldom used. By manipulating the air valves just as the engine comes to rest it is not difficult to bring the air cams in starting position so that no time need be lost in barring the engine around to the position for starting.

TAR ELIMINATED IN THE PRODUCER.

A notable feature of the producer plant is that it is capable of gasifying bituminous coals without making quantities of tar. The process is intermittent, embodying the now more or less well known system of passing the green hydrocarbon distillates through a secondary fire bed which has previously been brought up to the proper temperature by blasting with air. Since the plant was started, a fair grade of soft coal (B. R. & P. run of mine) has been used, averaging about 13,500 B. T. U. per pound. Although this coal presumably contains 35 per cent of volatile, tar destruction in the producers is complete, but at the same time a considerable quantity of lampblack has resulted which has made it necessary to devise special means to handle this by-product. No attempt has been made to market it, as some is used in the preparation of paints for castings, etc.

Straight producer gas is not made directly, but water gas and air gas are made at alternate intervals of varying duration according to richness of the gas desired. In metallurgical plants the two gaseous products of the system are often handled separately, the water gas being used for heating furnaces on account of its high flame temperature and the blast gas in gas engines for power purposes. And it is an interesting fact that, although this blast gas would be absolutely unfit for any other use on account of its comparatively low calorific value—from 80 to 90 B. T. U. per cubic foot—yet it is quite suitable for gas engine work, in that it is not at all snappy (as is water gas) and, therefore, permits of higher compression. At Depew the two gases are mixed in a single holder in the proportion generated.

In this system two producers constitute a unit. Usually it is desirable to have a separate unit on hand for relay purposes. Here this was especially necessary in order to provide an opportunity for freeing the producer from clinker formed during the week's run. At Depew a novel arrangement was first employed, in the form of a clover leaf with three producers united at top and bottom by T pipe connection with the necessary water cooled valves. It was then possible to renew one producer fire per week in rotation, and at the same time save the cost of a fourth producer to complete the duplicate unit. Through no fault of this arrangement, however, it was not an entire success, owing to the difficulty in preventing the leakage of water gas into the idle producer through the valves. This difficulty has now been overcome and a complete relay plant, including scrubbing equipment, is provided in the adjoining producer building with sensibly better results than before.

PRODUCER AUXILIARIES.

A feature of the system is that all steam required is generated entirely from the sensible heat of the gases coming from the producers which would otherwise be wasted in cooling water. This condition, however, obtains only when the plant is heavily loaded. Running light it would be difficult to make sufficient steam to operate the producer auxiliaries. An air auxiliary boiler would have to be drawn upon. With the high "heats" necessary in the intermittent process, this represents an important saving. The boiler, however, requires weekly cleaning.

The proper cleaning of the gas is a difficult problem, owing to the fact that lampblack does not easily adhere to a wetted surface as does ordinary cinder dust. In this plant the gas first passes upward through a wet scrubber containing several tiers of small coke constantly wetted down by water sprays. A thin layer of dry excelsior is also used in the top tiers. Emerging from the wet scrubber, the gas enters two large dry scrubbers filled with several tiers of excelsior and piped up in parallel so that the velocity of the gas is not only reduced but also the amount of gas handled by each drier. Finally, an engine driven Root's exhauster delivers the gas to the holder.

The various valve movements are handled mechanically by rack gears with operating wheels conveniently placed on the level of the operating floor.

PRODUCER OPERATION.

The present method of operating the producer plant requires an air gas run of 10 to 15 minutes, according to the demand for gas at the power plant, and a water gas run from one-half to three-quarters of a minute, the resulting mixture being well suited to power work.

Frequent testing of the quality of the gas made is not now practised on account of its uniformity under the present operating condition. The holder, of course, greatly assists in insuring uniform gas at the engines. At the same time it provides sufficient capacity for operating one unit at full load for about three-quarters of an hour; the full plant in inversely proportionate time. Storage capacity is particularly valuable when a new fire is being put into service. This is usually done during the noon hour when the load is light, so that a lowering of the heat value of the gas is relatively unimportant.

In ordinary operation it is a simple matter to observe the quality of gas by means of two sampling flames always in view of the operators. One consumes gas from the holder; the other consumes freshly made gases as they leave the dry scrubber. Any irregularities may then be readily detected. Calorimeter tests show the gas as made at the present time to average slightly above 100 B. T. U. per cubic foot (see Table 5). This comparatively low heat value is, of course, due to the preponderating period of blasting. With the rate of water gas mixing practically fixed, the only variable factor to compensate for varying demands for gas is the rate of blasting; hence, there is a long and subdued air gas run with a rapid but short run on water gas. During the second test (Table 5) the gas consumption was observed to be about 1,100 cubic feet per minute at a load of 395 kilowatts. This is equivalent to 167 cubic feet per kilowatt-hour at seven-eighths load on the generating units, and represents approximately a duty of 16,700 B. T. U. per kilowatt-hour, or a little over 11,000 B. T. U. per B. H. P. hour.

Coal consumption is determined by direct weighing in the producer house. Each shift weighs up enough coal at the start to run the plant through twelve hours; should there be a surplus at the end, it is weighed back and charged to the next shift, thus mak-

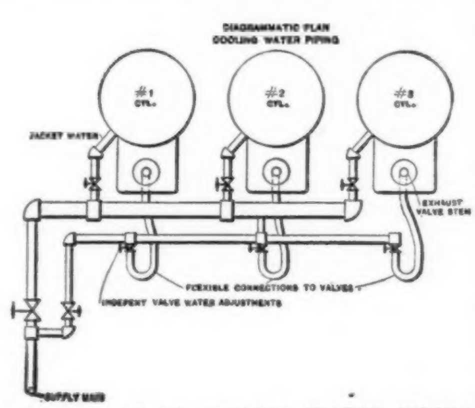


FIG. 8.—PLAN OF COOLING WATER PIPING FOR CYLINDERS AND EXHAUST VALVES

ing each shift responsible for all fuel used during their run.

The entire producer plant is operated throughout the week by four men, two to a shift, with some additional labor on Sundays for cleaning. All the attendants were unskilled foreigners before taking up the producer work. During a half day shut down of the plant on Sundays, all renovating of the producer equipment is done; boiler tubes are cleaned, wet scrubber washed down, the excelsior in the dry scrubbers taken out and shaken free from lampblack, gas mains flushed out and a new fire started in the idle producer. At the same time, another producer is taken out of service, fires are drawn, and during the week, after it has had an opportunity to cool off, the hard clinker,

Table V.—Characteristics of Power Gas.—Typical Analysis.

Date, June, 1905	20th.	21st.	23d.
Number of hours test	8	10	10
Intervals of tests (minutes)	15	15	15
Minimum calorific value	98	91	91
Maximum calorific value	113	110	104
Average calorific value	105	100	100
Maximum variation from average	7½%	10%	9%

Date.	H.	CO.	CH_4	O.	CO_2	N.
September 9, 1905	9.50	21.0	1.9	0.6	6.5	60.9
September 12, 1905	10.13	22.8	2.2	0.4	5.6	58.9

which adheres to the lining, is broken off. For the starting layer of a new firebed, coke is used to the extent of some 3,000 pounds per producer, a sufficient quantity to affect the coal consumption of the succeeding day. If allowed to form to any extent, clinker constitutes a frequent source of trouble in operating the plant, and it is important that the selection of coal be made with this in view. With fires fairly free from clinker the suction required for blasting may be only 8 to 10 inches of water, but with fires badly clinkered it may run up to 25 inches. With 10 to 15 inches drop in the scrubbers, this imposes from 30 to 40 inches suction on the exhauster, thus largely increasing its steam consumption.

GAS-ENGINE TYPES.*

By JONAS F. KING.

THE various members of the mechanism which make up the gas engine are susceptible of many different arrangements and it is sometimes surprising to read and hear the different arguments advanced in favor of one arrangement over the other. These apply more particularly to the type, number, and position of the cylinders. One seldom hears mentioned the character of the service when discussing the merits of various types, yet this should be the common starting point of all such discussion.

It has been the privilege of the writer to examine the findings of a commission of competent engineers employed by a large corporation to examine carefully the whole subject of gas engines, and it may be interesting to know what their ideas are concerning this matter of gas engine "type."

It is well to recall in the first place that most gas engines operate on either the four-stroke or two-stroke cycle and are either single-acting or double-acting according as one or both ends of the cylinder are utilized for the generation of power. The arrangement of the cylinders offers another natural division of classes or types and about every possible combination seems to have been used. It is assumed that the reader knows the meaning of the terms used to describe cylinder arrangement, such as tandem, twin tandem, opposed, etc.

Comparing the different cylinder arrangements on the basis of fuel economy, there is no marked difference between the single-acting and the double-acting machine. On the other hand, there are in this respect vital differences between the four-stroke-cycle and the two-stroke-cycle types. The four-stroke-cycle engine operates during the suction and exhaust strokes with pressures departing but slightly from the atmospheric line, and it consequently consumes small power in these operations. Furthermore, the power stroke is a complete piston stroke, and consequently a full diagram of useful work is obtained. In the two-stroke-cycle engine, on the contrary, the scavenging air and the gas and air mixture must be forced into the cylinder under a pressure of 5 to 5½ pounds per square inch in order to quickly supplant by a fresh charge the products of combustion remaining from the previous stroke. The power consumed by the necessary pump is considerably higher than the negative portion of the diagram in the four-stroke-cycle machine. Under the very best conditions, the former will amount to 10 per cent and the latter to 4 per cent of the brake horse-power developed by the engine. In this respect the Oechelhäuser engine, with its long cylinder, gives results considerably superior to those obtained with the Körting engine; in the latter the power absorbed by the charging pump was, in earlier tests conducted by Prof. Meyer, found to be 15 or 16 per cent, and in later tests as high even as 26 per cent. To a great extent this excessive figure was due to faulty construction of the charging pump; nevertheless, in the matter of proportion of power absorbed without return, the four-stroke-cycle machine will always maintain its superiority.

In the two-stroke-cycle machine there exists the danger that portions of the fresh charge will escape through the exhaust ports together with the outflowing products of combustion, and the additional disadvantage that in consequence of the necessary early opening of the exhaust ports, the indicator diagram of the engine cannot attain the same fullness as that of the four-stroke-cycle engine. On a basis, therefore, of economy only, the four-stroke cycle would hold the advantage.

The question of economy is at the present time, however, not of nearly as vital consequence as is that of reliable continuous operation, and in this respect the advantage must accrue to the machine possessing the smallest number of parts and the greatest accessibility. From this latter standpoint, a comparison between the single-acting and double-acting machines is in order and will show results entirely in favor of the single-acting. The most sensitive portion of the engine is the valve gear, which in a double-acting machine is, of course, doubled in quantity. Furthermore, the trunk piston of a single-acting machine may be quickly and easily removed; while in the case of a double-acting machine at least one cylinder head must be taken off before access can be had to the piston and valves. In large units as now built, the single-acting machine would, however, require cylinders and flywheels of excessive dimensions; the tandem arrangement reduces the accessibility, while the twin arrangement multiplies the moving parts, and both require the same quantity of valve gear as a double-acting cylinder. Nevertheless, developments were carried on in these directions, and the twin tandem and double twin engines designed and constructed in order to avoid by every means possible the use of an inclosed piston, but after the practical limit with four single-acting cylinders had been reached, there remained no other course but to turn attention to the double-acting construction of the four-cycle system. The first large engines on these lines have recently been put into operation, and it may be with certainty expected that this type of machine will, for large units, very shortly entirely supersede the single-acting four-stroke-cycle type.

The principal source of trouble in all four-stroke-cycle engines is the exhaust valve. This is, during the entire period of the expulsion stroke, subjected to the action of the hot products of combustion, and is, therefore, invariably provided with water cooling. Furthermore, this valve will rapidly foul, as there are deposited upon it and its seat dust and impurities which are not separated from the gas until combustion takes place, and this deposit of dirt causes leaks. These troubles do not apply to an equal extent to the inlet valve, which is cooled by the inflowing fresh charge, and with a sufficiently thorough cleaning of the gases there is no tendency of dust or impurities to settle upon its seat.

For this reason, it is of decided benefit if the exhaust valve can be done away with, and it is in the possibility of accomplishing this that lie the great advantages of the two-stroke-cycle machines so far constructed. All the objections and doubts expressed by the builders of four-stroke-cycle machines, to the effect that the outflowing gases at their high temperature would cause trouble by burning off the lubricant around the exhaust ports, have not materialized, although in Hoerde (Germany) the first two-stroke-cycle engines using such slots have been in operation more than five years, and that with comparatively unclean gas. A further advantage of the two-stroke-cycle machine lies in the cleaning and cooling effect of scavenging air.

The Oechelhäuser engine requiring neither exhaust nor inlet valves, would be an excellent machine were it not for its unavoidable three-throw crankshaft. Experience so far has proved this three-throw crankshaft reliable in operation; but it necessitates considerable floor space, especially in the twin arrangement, while it renders the construction of the engine as tandem or double-acting practically out of the question.

In his two-stroke-cycle engine Körting attempted to overcome these undesirable features, and his machine shows a successful combination of the least objectionable of them. It has only one row of exhaust slots and no valves other than inlet valves, and the difficulties with these latter are considered as successfully surmounted in Europe, where so much experience in the use of poppet or disk valves with superheated steam is available. The single-throw crank permits a simple and cheap frame construction. It must, however, be added that the two-stroke-cycle double-acting machine designed by Körting has not by any means attained perfection. The piston is difficult of access, and the charging pumps are very imperfect. The further development of this engine will, however, probably not be confined to Körting, as its principle is that of the old Clerk system, and only isolated details, such as the manner of gas inflow and the method of gas and air distribution, have been protected by patents. In Glasgow (Scotland), for instance, a company has been organized to develop and put upon the market double-acting two-cycle engines under the Vogt patents; its first small experimental machine was tested by Prof. Capper, of London, and gave satisfactory results, but fuller particulars have not been accessible. In the further development and perfecting of the two-stroke-cycle engine, there is little probability that Körting, with his wide experience in this line, will be left behind.

It may appear from the foregoing that all the advantages claimed for the two-stroke-cycle engine have been gained merely by transferring to the charging pumps the objectionable features of the working cylinder, for the pumps require valves and valve gearing and are, therefore, also liable to interruptions in operation. The fact is however that these parts are subjected neither to the high pressures nor to the high temperatures existing in the working cylinder, and that therefore they present no difficulties beyond those of ordinary low-pressure compressors.

The following is a brief summing up of the foregoing considerations regarding the various systems:

1. The four-stroke-cycle single-acting single-cylinder engine, in consequence of its irregularity, in spite of extremely heavy flywheel, will be limited in use to small units, say up to about 300 horse-power, and to installations where parallel running of electrical machinery is not necessary and constant voltage not essential.

2. The four-stroke-cycle single-acting twin engine, with cylinders on opposite sides of the crankshaft and connecting rods coupled to the same crank-pin, will probably be abandoned in consequence of the poor distribution of work in spite of the doubled moving parts.

3. The four-stroke-cycle double-acting single-cylinder engine is preferable to the last mentioned because of its single set of moving parts, but limited in application in consequence of its poor power distribution.

4. The ordinary four-stroke-cycle single-acting twin engine with its excessive inertia, and the counter twin engine of same system with its expensive two-throw crank, will also probably be abandoned.

5. The four-stroke-cycle single-acting tandem engine is cheap and reliable, especially for the operation of blowing cylinders, but requires great length of floor space, and is therefore difficult to oversee. The difficulties originally anticipated from the use of stuffing boxes have been entirely overcome.

6. The single-cylinder Oechelhäuser engine, having no valves, is a particularly reliable machine for driving direct-coupled blowing cylinders, and will probably maintain its advantageous position in this respect.

7. The four-stroke-cycle single-acting double twin engine has proved itself reliable, especially for driving direct-connected dynamos set between the two sides; particularly alternating-current generators. Nevertheless, it must not be forgotten that this arrangement resulted from a fear of using stuffing boxes, and will, therefore, certainly be abandoned, on account of its expensive construction.

8. The four-stroke-cycle single-acting double tandem engine will probably share the same fate, and for the same reason, i. e., high cost of building.

9. The four-stroke-cycle double-acting tandem engine will take the place of the two last mentioned, especially for driving alternating-current generators, as it combines the high exactitude of regulation of the four-stroke-cycle machines (7) and (8) with fewer moving parts, and is less expensive to build.

10. The four-stroke-cycle double-acting twin engine is more expensive than the last mentioned, and will, therefore, be preferred only in cases where the floor space available will not permit the use of the tandem arrangement.

11. The twin Oechelhäuser engine possesses the advantage of an excellent counter-balancing of the moving parts, and is, therefore, suitable for the parallel operation of alternating-current generators, provided the difficulties in regulation which the earlier machines possess shall be overcome, which is unquestionably possible.

12. The two-stroke-cycle double-acting machine is well adapted for driving blowing cylinders and electric machinery, and will, without question, become and always remain a desirable arrangement.

13. The four-stroke-cycle double-acting double twin engine, and the two-stroke-cycle double-acting twin engines possess all the advantages of the single machines (10) and (12) with an even more exact degree of regularity, and are undoubtedly the best available arrangements for very large units, particularly where electric generators are to be run in parallel. Of the two arrangements, the former will be the more economical in gas consumption, and where producer gas is used, will remain the most desirable machine for large units in which with fewer cylinders the dimensions of machines would become excessive.

* Power.

THE PHYSICAL MEANING OF POWER-FACTOR.

THE student of electrical engineering has a powerful tool put in his hands in the mathematical process of dealing with harmonic motion. All alternating-current theory is based upon the idea of simple harmonic forces. It is true that it is well recognized in practice that this condition seldom prevails; but it is, in many cases, very closely approximated to, and in all cases the results obtained by this method of treatment may be modified so as to give values which are accurate enough for all purposes. To-day we know a great deal more about the modifying reactions and forces which are encountered in our electrical supply systems and devices, and have thus been able to extend the mathematical theory so as to allow for them.

Another great advantage to the student is the use of graphics—diagrams representing the relations of the various forces and quantities under consideration. These present to him a picture of a foundation, upon which he can build up his ideas and from which he can deduce results. These two methods of graphical analysis and the algebra of harmonic motion are essential to all students desiring more than a superficial knowledge of alternating currents.

It is the general practice, therefore, to introduce the student to the subject through these two methods—in fact, in no other way can he so clearly arrive at an understanding of the subject. But the instructor should always point out the limitations of the methods, and he should show that as soon as the phenomenon departs from a simple harmonic motion the methods must be modified accordingly, or the results which they give should be interpreted with the modifications in mind; otherwise discrepancies and misleading conclusions are apt to be drawn.

An example of this kind is sometimes met in determining the power-factor. In the simple mathematical treatment the power-factor is defined as the cosine of the angle of the phase difference between electromotive force and current. It is shown that by multiplying together the effective values for current and electromotive force and introducing the cosine of the angle of phase difference as a factor that the true power is obtained. In the graphical treatment this definition results directly from the method. The power is, of course, the product of either one of the vectors by the projection of the other one upon it, and this projection is equal to the projected line multiplied by the cosine of the angle.

If, now, the curves be not sinusoids, a difficulty in determining the power-factor in this way will be met. It may be found that although the two curves cross the axis at the same point, the power, as measured by a wattmeter, will be less than that given by the product of the effective values—that is to say, although there is no phase displacement the power-factor is less than unity. Some have sought to avoid this inconsistency by considering this phase displacement as that separating the maximum points of the two curves, but here again the same trouble may be encountered; and, moreover, one curve may present two or more maxima. The trouble is simply one of definition, and disappears if a proper one be made. If in the first place, the power-factor be defined as the ratio of the true to the apparent watts, there is no difficulty. Then it may be shown that with simple harmonic curves this ratio is always equal to the cosine of the angle of phase displacement. Moreover, when defined in this way power-factor has a physical meaning, while if one adhere to the mathematical definition one is frequently in a quandary. What, for example, is the power-factor of an unbalanced polyphase system? Taken as a ratio of true to apparent watts, there is no uncertainty.

This subject—the physical meaning of power-fac-

tor—is very interestingly discussed in the Journal of the Franklin Institute for December by Prof. Albert F. Ganz, who shows peculiar wave forms obtained from various electrical devices now in use, which illustrate very nicely the necessity for a clear understanding of the physical meaning of power-factor.—Electrical Review.

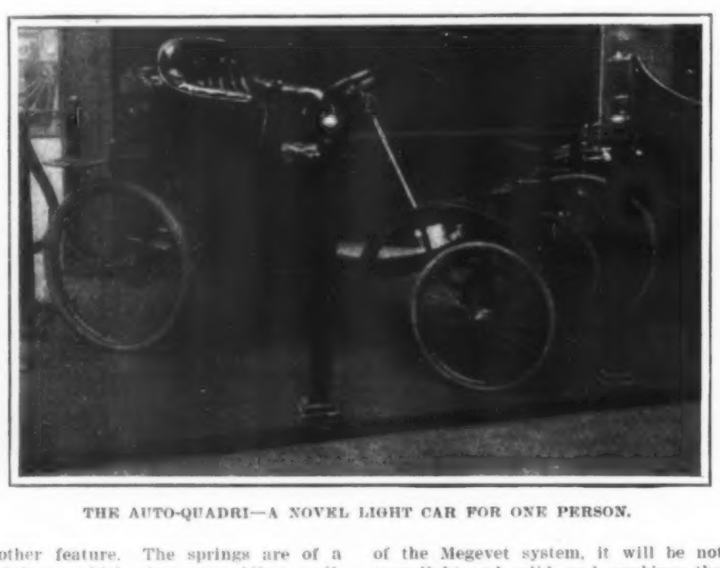
NOVELTIES OF THE PARIS AUTOMOBILE SHOW.

By Our PARIS CORRESPONDENT.

THE AUTO-QUADRI.

THIS novel light-weight car resembles the motorcycle in some of its features, and in others it follows the lines of a voiturette. By its simple construction, small size, and low cost, it comes into the quadricycle class, but it is designed quite differently from the latter, and approaches the voiturette in general appearance and comfort. The accompanying photograph shows this original form of automobile, which merits a brief description, since it may be the solution of an economical car for general use. The inventor's plan is not to look upon the voiturette as a reduced copy of a large car, in which cheapness is secured at the expense of solidity and finish, but to make an altogether different design. The motor is built in a compact group along with the transmission, clutch, and differential, all of which are contained in a single case resting upon the rear axle and placed behind the body of the car. The system of speed-changing, which is a patented feature, consists of two conical clutches which give two speeds; and it is to be noted that on both speeds there is a direct drive, without intermediate gearing. As the motor drives the rear axle directly, there is no appreciable loss of power. It is to be observed that all the different types of auto-quadri, whether of one or two places, are fitted with water-cooled motors. The water circulation is carried out on the thermo-siphon principle, and the radiator is placed at the front of the car.

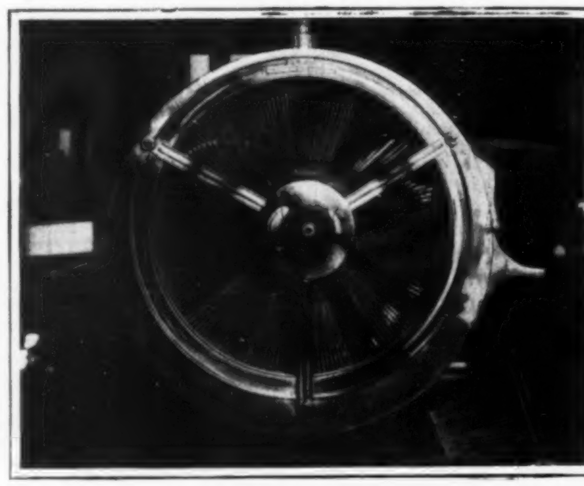
Pedal-operated brakes on the rear wheels are fitted in addition to the usual differential. All the working shafts run in ball-bearings. Thorough lubrication of all working parts by means of separate pipes connecting with a single sight-feed lubricator supplied from an oil tank, is another feature. The springs are of a special elongated form, which gives easy-riding qualities to the body. The inventor has also designed a new form of motor starting device which he expects to apply on all the vehicles, so that they can be started up automatically from the driver's seat. For the single-seat car, which is the one illustrated, a $2\frac{3}{4}$-horse-power motor is used, or a larger one of $3\frac{1}{4}$ horse-power. Above the motor, on the back of the body, is placed a cylindrical gasoline tank. With the larger motor, 20 miles an hour is obtainable on the high speed, while a low speed gear giving 5 miles an hour is also fitted. A machine for two people is also to be built on the same plan, and this will be fitted with a $5\frac{1}{2}$-horse-power motor.



THE AUTO-QUADRI—A NOVEL LIGHT CAR FOR ONE PERSON.

THE MEGEVET ROTARY RADIATOR.

A considerable number of radiators were shown this year by the principal firms, but most of them are simply improvements upon the well-known standard forms and designed with different shapes of radiating wings or water cells so as to secure an increased cooling surface. We note, however, a somewhat novel apparatus which departs from the usual construction. It has been designed by the Swiss firm of Megevet & Company, of Geneva. What is original about the "Triplex" radiator, as it is called, is the fact that it combines in a single apparatus not only the radiator proper, but the air-fan for the motor, and the water pump. The general appearance of the Megevet radiator will be seen in our illustration. It is built in a compact form and can be placed either in front of the motor in the usual position or else behind the motor, or even in any other part of the chassis. It works in a very simple way. The central hub is hollow and the blades of the air-fan are made up of a set of copper tubes of small diameter which join the hub to a short outer section at the end of each blade, so that the water can circulate freely in the pipes. The hot water coming out of the motor jacket is brought by a pipe to the center of the hub, and it passes thence through one part of the copper tubes of each wing, coming back to the center by the second half of the set. In the center of the hub is placed a special pump which forms part of the hub itself, and the pump sends the water to the circular brass tank which will be noticed surrounding the air-fan and forming the body of the apparatus. This method gives a very good cooling for the water, and it is found that in passing through the copper tubes while the fan is in rotation the water is cooled immediately. The apparatus consisting of fan and circular reservoir has but a small weight, this lying between 40 pounds for a 16-horse-power motor and 52 pounds for a 40-horse-power size. As a steam condenser it works very efficiently, and it is built to stand pressures of thirty or forty atmospheres. As to the advantages of the Megevet system, it will be noticed that it is very light and solid, and combines three different apparatus in a single one. It can be easily taken off the car, and is not likely to get out of order.

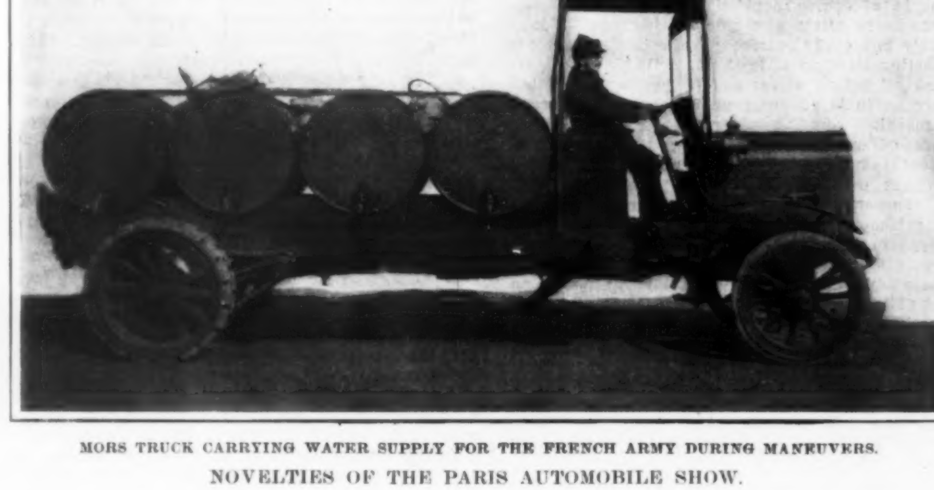


A NEW FORM OF ROTATING RADIATOR.

This radiator is made up of twelve sections that rotate about their central axis and effectually cool the water without the use of a fan.

THE MORS ARMY AUTOMOBILE WATER WAGON.

The Mors firm showed a heavy-weight car which is specially designed for army use. Upon the chassis are mounted a number of cylindrical tanks intended to carry a supply of drinking water, since the car is to be used in the field maneuvers of the army. During the recent trials it was found much superior to the old methods of bringing on the field the water which is needed for the different detachments. In the army maneuvers of last September, which were held at the fortified post of Langres and the surrounding region, it made a good performance, and the Etat-Major was greatly pleased with it. This is another example of the favor which the automobile for different purposes is meeting with in the French army, as well as in other countries of Europe. The problem here consisted in supplying the detachments which were stationed on the heights above Langres and in transporting some 1,000 gallons of water per day over roads which had been badly cut up by the passage of the siege guns and troops, besides the construction of the strategic railway. For this reason the conditions were especially hard. The good performance of the present 28-horse-power car consisted in transporting the water supply daily for twenty days over a very hilly and broken region, and it showed the service which the army can secure by the use of the modern automobile. At the show were also noted two armored cars for carrying light field guns in a tourelle. One of these is brought out by the Charron-Girardot-Voight firm, and the second by an Austrian firm. Both of them we have already described, and there has been no change made upon them since. Among the heavy-weight cars which are somewhat novel is one which the Peugeot firm is bringing out for the collection of garbage. This wagon is intended to replace the ordinary one used by the municipality of Paris throughout the city. It has a large steel body capable of carrying a considerable load.



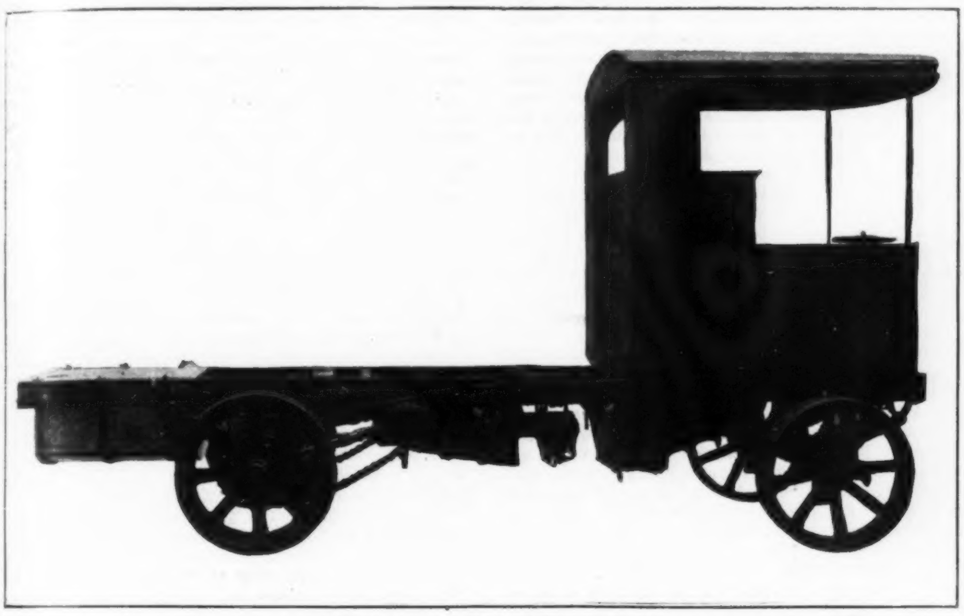
MORS TRUCK CARRYING WATER SUPPLY FOR THE FRENCH ARMY DURING MANEUVERS.

NOVELTIES OF THE PARIS AUTOMOBILE SHOW.

CHABOCHE STEAM TRUCK.

This year there were a great number of heavy-weight cars exhibited at the show, and this feature of the automobile industry is becoming very important in France and elsewhere on the Continent, where the good roads will allow the use of the omnibus and hauling cars for long distances. Gasoline omnibus lines are coming into use quite extensively in the rural districts and are found a great convenience. In a number of the large cities omnibus lines are running for passenger use, and while Paris has been much slower to take up the matter, owing to the difficulty of making the proper arrangement with the companies, there are now several gasoline omnibus lines in operation, and they are greatly favored by the public. On some of the Berlin lines an electric omnibus of the Krieger type is being used. One of the novelties in the way of a truck is the Chaboche system which is applied to this kind of vehicle for the first time this year. We have already had occasion to speak of the steam system used by this firm, which consists of a flash tube boiler, fire-box, engine, and condenser. The car which is illus-

trated here is designed to take a heavy load. It uses coal or coke in the fire-box, and the motor gives thirty horse-power, being of the two-cylinder type. The flash-tube boiler uses only 350 grammes (¾ lb.) of coal per ton-kilometer.



THE CHABOCHE STEAM TRUCK CHASSIS.

This machine is an economical heavy-weight hauling vehicle that employs coal for fuel.

The present car will take a net load of 6½ tons and can run on a twelve per cent grade. Unlike the steam automobile car, which uses a gasoline burner, the truck is designed to burn either coal or coke, with or without an automatic stoker. In any case, the stoker brings the coal upon an inclined grate which always has the proper layer of coal. By tripping it up it can be readily cleaned through two opposite doors. The use of condensation in this type of boiler is claimed to entirely suppress incrustation. As in the oil-fired car, the boiler pressure is regulated automatically. Of the two-cylinder type, the 30-horse-power motor is well inclosed in a casing partly filled with oil. Besides the crankshaft the box has two countershafts, the first containing two speed changing gear sets and a clutch while the second shaft carries the sprockets for the chain leading to the rear wheels. After leaving the motor the steam passes into a condenser having a mechanical draft, and the condensed water returns to the tank. The present illustration shows the chassis of the truck, which is built of steel, and can have a variety of car bodies mounted upon it to suit the purpose.

THE SAURER MOTOR-STARTING SYSTEM.

Automatic systems for starting the motor of a car were among the features of the recent show. These systems are intended to replace the hand crank, and the driver no longer has to leave his seat in order to start the motor, as the various devices used enable him to start it by simply working a lever. A number of methods are used for the purpose, some of them working by a spring, others by a small electric motor supplied by a storage battery, and others by compressed gas stored in reservoirs. In the Saurer system compressed air is made use of for this purpose. This new system was brought out by a Swiss firm located at Arbon. Its working is based on the fact that when a four-cylinder motor comes to a stop, the cranks assume a horizontal position, since the piston that stops during the expansion stroke is in equilibrium at half-stroke with the piston in the compressing cylinder. Thus, when the motor stops, there is always one cylinder in which the expansion stroke is but half finished. By sending compressed air into this cylinder from a tank, even with a pressure as low as 60 pounds per square inch, the resistance of the other piston which rises on the compression stroke can be overcome, although the compression of the latter may be greater than this figure. The reason of this is that the maximum compression takes place only at the end of the stroke, when the momentum gathered by the acceleration of the fly-wheel, etc., aids the force of the compressed air. Upon the next stroke, the air is sent into the compressing cylinder in turn, so that the speed of the crankshaft increases. By this method the motor operates as a four-cycle engine, as usual, but the explosions that ordinarily occur are replaced by the action of the compressed air. A high speed of the motor is secured at once by this method. Then charges are drawn in and the ignition is set working, whereupon the motor operates in the usual manner. The diagram shows the essential parts, and the operation of the device will be readily understood from the following description:

An air pump, *a*, which is thrown into action by a clutch and is driven from the main motor shaft that extends back from the motor to the gear box, supplies the air reservoir, *b*, with compressed air at about 100 pounds pressure. For starting the motor, the driver's hand lever, *c*, is placed in the third position, which has the effect of opening the valve, *e*, that connects the air reservoir with the motor and thus admits air to the distribution slide valve placed on the upper part of the motor at *d* and operated from the camshaft. The distributing valve is used to admit the compressed air into the different cylinders of the motor in turn, according to the position of the crankshaft, and the air enters each cylinder by a special automatic spring inlet valve, *g*, after which the rotation of the motor commences. The spring valves are closed by springs which are regulated so that they are not opened by a depression of 3/10 of an atmosphere within the cylinder, while they yield to the pressure caused by the compressed air upon the outside. The three positions of the hand lever correspond to (1) the motor driving the air pump to fill the reservoir, (2) the pump unclutched or the position of rest, and (3) the pump remaining still unclutched, and the air reservoir connected to the motor. In case of long stops of the car, the compressed air can be shut off at a point near the tank by a separate hand valve, *k*, so as to avoid leaks from the working valves. Several advantages are given by the above system, among which may be mentioned the easy operation by a lever without effort on the driver's part, and which makes it possible to repeatedly start the motor, even when it is cold. The motor at once attains a speed approaching the normal, and hence a good mixture of gas and efficient ignition results. The

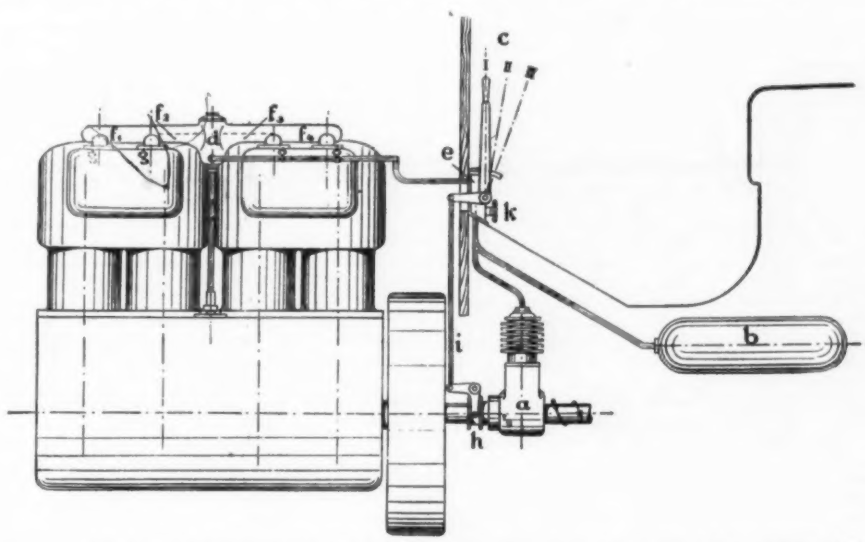
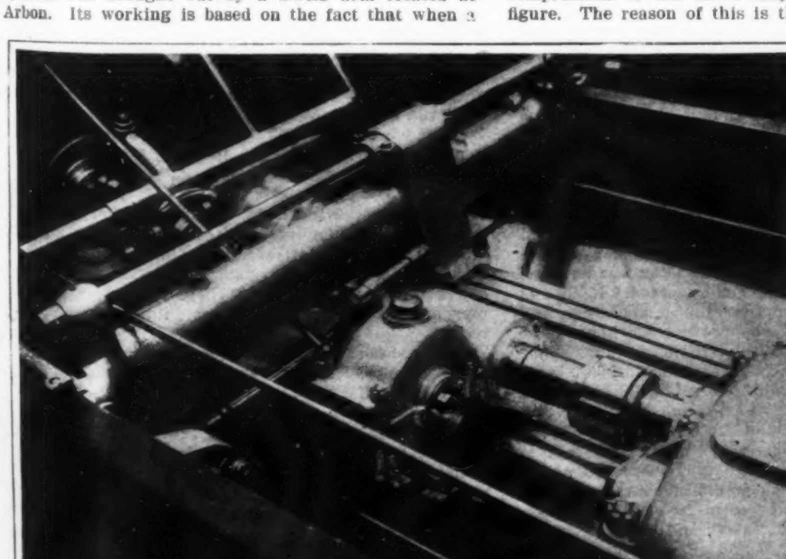


DIAGRAM OF SAURER COMPRESSED AIR STARTING SYSTEM AS APPLIED TO A 4-CYLINDER MOTOR.



AIR COMPRESSOR OF THE SAURER AUTOMATIC STARTING SYSTEM.

The driving gear of the air compressor, located on the shaft running from the motor to the transmission, can be locked to this shaft by a clutch when it is desired to fill the reservoir with compressed air.

THE 24-CYLINDER, 360-HORSE-POWER LEVAVASSEUR GASOLINE ENGINE. WEIGHT, 3.6 POUNDS PER HORSE-POWER.

This engine is in reality three 120-horse-power, 8-cylinder engines assembled on one crank case. The two high-tension distributors are to be noted at each end, driven from the half-speed camshaft.

NOVELTIES OF THE PARIS AUTOMOBILE SHOW.

device can be fitted to any four-cylinder car. The compressed air can also be used for inflating the tires, for which purpose it will be found exceedingly convenient.

THE LEVAVASSEUR 24-CYLINDER, LIGHT-WEIGHT, V MOTOR.

The Levavasseur Company has recently finished building a new light-weight motor which attracted a great deal of attention at the show. We have already described the leading features of the smaller motors of this type, and it will be remembered that by using a number of improved mechanical features in their construction, M. Levavasseur succeeds in reducing the weight per horse power to probably the lowest figure which has yet been reached. On this account the "Antoinette" motor is now meeting with great success for motor launches, but especially is it used in the aeronautic field, where it has been adopted by Santos Dumont, Capt. Ferber, and other aeroplane workers. The size of the motor has been gradually increased, and following the first 25-horse-power type came a 50-horse-power, which was adopted on some of the aeroplanes. But the present motor goes far ahead of these, since it is designed for 360 horse-power, and is by far the largest light-weight motor ever built. It weighs 600 kilogrammes (1,322¾ pounds) which brings the weight per horse-power down to 3.67 pounds. Consisting of three 120-horse-power units of eight cylinders each, mounted on a common crankcase, the motor has twenty-four cylinders in all, with a 150-millimeter (5.905-inch) bore and stroke. Aluminium is largely used in building it. Hollow steel shafts reduce the weight, and the cylinders are turned inside and out, and fitted with sheet brass water-jackets. The total length of the motor is about 3 meters (9.84 feet) and it makes 900 revolutions per minute. It is designed to be mounted on a racing launch which is under construction, and has been already entered for next year's races at Monaco. We have already illustrated one of the former boats fitted with the Antoinette motor.

The several novel features of the Levavasseur motors were fully described in SUPPLEMENT No. 1612, to which we refer our readers for further details.

THE WORK OF THE ENGINEER.*

WE have been told—and we are very ready to believe good of ourselves—that the engineer is the most powerful instrument of civilization and progress which exists, because without him there would be no railways, no steamers, no telegraphs or telephones, no electric power to be distributed free to everybody, no motors, and hardly even the roads for motors to run on, with which latter, by the way, engineers have scarcely yet been able to furnish us. It all sounds very obvious, and we may each congratulate the other for his share in the stupendous engineering progress of the last half-century. It is always pleasant to feel ourselves very superior persons and still more pleasant to be convinced that in earning our daily bread we have been also conferring high moral benefits on our fellow men.

I do not want to cool down the glow of satisfaction induced by the consideration of these views of existence, when enlarged upon by the more eloquent members of our profession. Possibly such ideas may even help some of us to do our work better, and, if so, they are of real benefit. But, if so, it can only be in the same fashion as that in which a foolish, or an unwise, or even a wholly misguided enthusiasm has sometimes led armies to victory; and it may be as well to take a more reasonable view of the relations between engineering and modern civilization.

The glorification of our profession, of which I have been speaking, while, as I have said, possibly useful to encourage us and keep us up to the mark, is, after all, surely due to reasoning in a circle. If we merely say that progress in engineering matters has been due to engineers we say what is true, and what is at the same time practically the whole truth. But we have no right to assume that if there had been no railways and no telephones, no electric light and no motor omnibuses, the world would have been a whit less civilized, less moral, or less happy than it is. It would only have developed along other lines than the present mechanical ones. While engineers also are so ready to take credit for what they have done, they have to remember that they must also take their share of the responsibility for it. It is quite easy to conceive of a civilization developed on unmechanical lines, under which our people might have been more thoughtful, better read (in everything except newspapers), less prone to absurd excitements about what we call "politics," less ready to join in united shouting about things they do not understand, less easily persuaded to bring the state even to the very brink of war with good friends and neighbors at the bidding of some "yellow" journalist, whose malicious ravings would never have had any circulation if we engineers had not provided the printing machinery and the special trains.

It is never safe to talk of "might-have-beens," but it is clear that it is mere begging of the question to assume that everything that has come about has been for the greatest good of humanity, that all the inevitable movement and change which goes on is toward improvement, or that the much misused word "progress" should always connote improvement at all. Do not many of us know in our hearts, at the end of a busy and worrying session—and all sessions appear to be busy and worrying—that we would contentedly sacrifice half our work, and more than half our incomes, if we could only live quietly and peaceably, have some breathing time to think and to see and to read, be a hundred miles from the nearest railway station, receive letters once a week, and know that telegrams cost a shilling a word.

This is by way of making it clear that I am not going to start on any discussion of the engineer with the assumption that he is the salt of the earth. But I do start from the position that, as his predecessors were responsible for starting the world on 100-pound rails when it refused any longer to jog contentedly along on macadam, he himself must now do all he can to see that the lines laid and being laid are leading in the right directions, and not assume complacently that all roads lead to perfection simply because he has put them down. However, the world intends to go by machinery for our time, at any rate, and we engineers are the drivers and the signalmen at the same time. I hope we may be able to do our work with a full sense of the serious responsibility of this double position. Can we cultivate such an ideal that our widely-extended influence shall really be for the benefit of the community, not only in giving them good railway service and cheap power, but in some wider and much more important fashion?

In relation to science, I have always claimed for engineers a very high place, a place much higher than some of my purely scientific friends are disposed to allow them. I really believe not a few engineers have spent their whole lives in scientific work while they were nominally only earning their daily bread in ordinary mechanical pursuits. Engineering problems differ from ordinary academically "scientific" problems, partly in that they are much more complex, and consequently more difficult of anything like exact solution, and still more because—exact or inexact—some solution to them has always got to be found. Not only must the solution be found, but it has to be translated into steel and gun metal, as well as into £ s. d., and any mistake will entail very much more serious consequences than a controversial paper in the Philosophical Magazine or a letter in Nature pointing out a wrong estimate of terrestrial radio-activity in prehistoric epochs.

But a word of caution—unnecessary to the experienced, but sometimes necessary nearer the start. The mere use of formulas or of exact calculations of any sort is not in itself scientific. That man shows far more of the scientific spirit who recognizes when his data do not allow of the use of any exact formulas, and who therefore reasons with what may be called mathematical common sense, than the man who tries to force the facts to fit a class-room formula, and arrives at a result which satisfies the formula, without recognizing that it bears no relation to the facts. The scientific engineer may use elaborate calculations or he may not; a most important part of the science lies in judging whether to use them or not. Conversely, the man who calculates elaborately may be working scientifically or he may not. The mere calculation is not scientific, and in certain cases may only be a cloak to essential defects both in scientific method and in technical perception.

Perhaps, in the early stages of human or of mental development, it is desirable that the mind should be nurtured on dogma—fixed, certain, and infallible—and, if so, the scientific dogma is probably the least poisonous variety of the species. But whatever may be the case at first, most men who have devoted their lives to science have come eventually to hold their original dogmas very loosely, and to recognize that they are, after all, only semi-crystallized versions of very imperfect knowledge. And the engineer, of all men, should have the earliest opportunity of working himself free from the youthful leading strings. From the day that his pupilage ends until the last day of his engineering life he is always face to face with the fact that there are half a dozen ways of doing everything, and that the half-dozen ways are more or less equally good. I suppose most of us carried our boyish cocksureness right through our pupilage, and left our first shops or offices with a notion that everything ought to be done exactly as it was done there. But the notion was dispelled with an almost overwhelming shock when we found out that elsewhere no one cared in the least what our people had been doing, but got the same results by quite different methods. The more we see of engineering work the better we know that none of our problems has one single solution, that all of them can be worked out to the same end in many different ways, and that it is very seldom indeed that, except as to some small detail, any one method is so much better than the others that it has any special claim to be called the right method. If this is the experience of our everyday life as engineers, and in relation to the things about which we know most and to which we have given a lifelong study, ought not we engineers to be able to set the world at large an example of tolerance and broad-mindedness in other matters and as citizens, which would not be easily reached by any other class of the community?

To what extent do engineer and artist come in contact? It can hardly be denied that there are points which at least ought to be points of contact in their work, although their paths seem frequently to intersect rather than to be tangential, and the intersection is too often at 90 deg.!

As regards machinery of every kind, from marine engines to sewing machines, we have come to recognize that at present our business is to use the material in the place where it is wanted, and of the form best adapted for the work which it has to do. Between moving machinery and architectural structures there is no analogy; and to apply to the one the classical rules or conventions of the other, as was once attempted to a certain extent, is surely a mistake in art as well as in engineering, and the eye has now recognized this. But it would imply, I think, a very narrow range of perception of things beautiful to deny a beauty of a genuine kind—although neither classic nor romantic—to an express locomotive, or to a great marine engine as it stands in the erecting shop. We used to compare the hard outline of the steamship, with its clumsy funnel and abortive masts, with the graceful lines of the three-master and the beautiful forms and color of her sails. But even already, although steamships are things as yet of our own generation, now that they have cut themselves adrift from all suggestion of imitation of their predecessors, everyone recognizes that there is a dignity in a "Dreadnought" which is almost majestic; and that the modern liner, properly handled, forms really as fine a subject for a picture as a full-rigged ship, although naturally the pictures are different.

But with engineering structures the case is different, and certainly the question is more difficult. We have to build—or to get built for us—bridges, viaducts, dams, stations, power houses, goods sheds, factories, and so on. All of them come into direct comparison with the ordinary structures designed by the architect and seen and judged by the public at large. Often, unfortunately and unreasonably, they are compared, not with the ordinary structures, but with the noblest of architectural buildings, and we are asked to compare, say, York Railway Station with York Minster, which is obviously unfair.

Perhaps our greatest difficulty in this matter is with our steel bridges. They are unavoidably so much in evidence that even "the man in the street" considers himself fully competent to form, and therefore to express, an opinion about them. I need not say that "the man in the street" is really able to do nothing of the kind, except, of course, to express an opinion. None the less it behooves us to take care what we are doing, not for the sake of the mere surface opinion of to-day, but in order that, by the time our work has become ancient, it may also be considered worthy of the respect due to age, and not the mere survival of an early Victorian period in the youth of engineering. Our first consideration should be—of course, after considerations as to strength and engineering suitability—that the form of the structure should be determined essentially by the material of which it is made, and not based upon the forms of older structures, however beautiful in themselves, built of quite different materials. The carved moldings and details which lend so much beauty to a structure of stone, are apt to impress us only as "cheap and nasty" when reproduced in cast iron. Similarly, the curves and scrolls of a Gothic pattern, if imitated in malleable iron on a structural scale, do not give the idea of beauty, but merely of material used in a wrong way. It would be impossible here, even if I had myself the necessary artistic knowledge, to discuss the question of how the lines of a structure—and our structures are all lines together—affect our sense of its proportions. But examples of structures which, although doubtless economically designed, are undoubtedly hideous, will occur to many. On the other hand, such structures as the Forth bridge here, or Roebling's suspension bridge in New York—many others might be named—are examples of what can be done to please the eye, while at the same time utilizing the material with every possible economy, and satisfying all the demands of scientific fitness.

At the risk, however, of being considered a Philistine, I feel bound to say that I do not consider a well-designed lattice girder—such, for example, as those of the Charing Cross bridge—to be in itself ugly. I make bold to say that after another forty or fifty years, if the bridge is still in its place, it will be recognized that a straight line is not in itself hideous—which seems to have been recognized long ago in Athens. And if it be once admitted in principle that a girder bridge, in spite of being straight, may be looked at without pious horror, the critics may cease to affect displeasure, and even come to regard such structures as simple and straightforward, and in their whole effect not at all unpleasing.

About engineering buildings the same class of questions does not arise. They must just take their place with any other buildings. If they are for purely industrial purposes, their form, and even their external appearance, must inevitably be mainly determined by their purpose. But even here we are most of us familiar with the extraordinary difference which a little artistic feeling can make by very small changes and at small expense, and I hope that in future we may not be so great sinners as in the past in this respect.

We expect architects to consult and employ engineers to help them over structural difficulties, and we may even scoff when they come to grief for not doing so. They are, on the other hand, quite entitled to turn the tables on us when they see that an engineer has put up a hideous barn which they could have transformed into a pleasing structure by their own special knowledge, and by that sense of form which it has been their chief business to cultivate, while we have been working at bending moments and breaking loads.

With another profession, that of the law, we are brought by our daily work into very close connection, so close that in many matters it is necessary for the engineer to carry out his work in the most strictly legal spirit, however undesirable it would be for him to be "his own lawyer." All engineering work of importance is carried out according to both a specification and a contract. An engineer prepares the specifi-

* Extracts from the Presidential Address of Sir Alexander B. W. Kennedy before the Institution of Civil Engineers.

cation and is practically responsible for the contract, while very often other engineers—from the manufacturing side—accept both documents and undertake to work them. There is little doubt that the more strictly legal, which means in this case equitable, the conduct of both parties is, in reference to these documents, the less is the probability that the aid of the purely professional lawyer will have to be called in later on.

On the manufacturers' side there is one chief and simple, but absolutely necessary, duty to perform in reference to these documents—namely, to read them. The duty is as simple and as obvious as "keeping your eye on the ball" in another phase of existence, and is just as often neglected. Hence many tears. If the contractor or manufacturer is dealing with a responsible and experienced engineer, he may be sure that the documents are intended to mean what they say, and that—barring mistakes—they do mean it. If, therefore, he finds that he cannot do what he is asked to do, there is nothing to be gained by slurring it over. The only means of avoiding trouble is the raising of all doubtful points before the work begins, so as to get them settled. If, on the other hand, the contractor is dealing with an irresponsible or inexperienced engineer, and no doubt there are such, it is all the more necessary that he should know exactly what he is asked to do. For in that case there may be meanings in the documents which only careful reading will discover, but which will certainly be taken care of, later on, against the contractor himself.

On the side of the engineer who draws up the specification, it is surely his duty, after drawing it up, after stating as clearly as possible his requirements, to endeavor to go through it from the point of view of the contractor, and make sure that there can be no reasonable doubt of the meaning of the words or phrases he has employed. This is every bit as true of the specification as of the contract; but whereas with the latter there is always legal help available, with the former the engineer has to trust to his own power of exact expression in saying just what he wants, and no more and no less than he intends to have.

The question of how much or how little to put in a specification is one about which no very general rule can be laid down. Naturally, much depends on the engineer, on the contractor or manufacturer, and on the nature of the work. But first and particularly it is the duty of the engineer to define exactly what results he wishes to obtain. If he is unable to say what he wants he can hardly be the right man for the work, and had better leave it alone. He can also say, quite exactly, the nature of the materials he requires to be used. In the majority of cases he can also say in what way the work is to be carried out, what machinery or apparatus or appliances are to be used. Or, if there are several ways in which his requirements can be met, he can indicate one of them and leave the contractor to suggest others. No doubt cases arise in which the requirements are such as can be fully met by certain methods or appliances only of a certain particular manufacturer or contractor, but in general a specification cannot be too full—it can certainly never be too clear in dealing with general requirements and results. But in details it may very easily be too full, and no greater mistake can be made—nor any mistake more likely to lead to vexatious litigation later on—than to crowd up a specification with detailed particulars as to matters which every competent contractor or manufacturer can carry out equally well in his own way. I would therefore put, as the characteristics of a good specification, definiteness, and clearness always, fullness as to requirements and as to guarantees, freedom and openness as to those details and methods which are largely matters where contractors have had very varying experiences.

Personally I have very strong views as to the inadvisability of making an engineer the arbitrator in relation to his own specification, although I know that some public bodies have different ideas. But even where the engineer is not the final arbitrator, there are sure to be many points of detail in relation to the carrying out of the work according to the specifications which he solely will have to settle. And in these it is very desirable that his attitude should be, as far as possible, that of an arbitrator rather than of a party to a dispute. It is really here that the special importance of definiteness and clearness in the original wording of his specification comes. If he has said exactly what he wanted in terms which could not reasonably be misunderstood—if they had been reasonably and carefully read to start with—he can make his decision as fairly as if he were an arbitrator. But if his specification has not been clear, or has been insufficient to start with, his decision must necessarily be colored by his own unexpressed intentions, his own view of what he meant; so that, although honestly given, it may not be by any means certainly the decision which an arbitrator would have given under the same conditions. Strictness, or even what is called severity, in a specification is not in itself against the interest of the contractor. As long as he can see what is wanted it is his business to prepare for it. If the contractor presumes on the engineer being slack in construing his requirements, that is his fault, and he is rightly penalized when it turns out that he has caught a Tartar. But a carelessly worded specification, or one in which important requirements are slurred over or only indicated inferentially, is unfair to the contractor, is unworthy of the engineer, and is likely to lead both into trouble as well as to result in unsatisfactory work.

With ordinary commercial life, every engineer stands in very close touch—the manufacturer, of course, directly, the consultant indirectly, but hardly less intimately. We shall not go wrong, any of us, if we can only make up our minds that, as to our work—whether hand work or brain work, metal work or paper work—its quality is the first thing to be considered, and that, as to ourselves no amount of profit is worth having if it is obtained by us as mere money-getting machines, and not as gentlemen. We are rather fond of talking loosely of engineering as a "profession." I am not sure what authority is entitled to say whether engineering is or is not a profession. It must be a very young one certainly, if it is one at all. But by all means let us call it a profession, and then let us do our work accordingly. I fear it must be confessed that with some engineers things have occasionally not been thought unworthy or improper which, although not in themselves dishonest, would be impossible among lawyers or doctors, which ought to be impossible among gentlemen, and which would be impossible among ourselves if our organization were as complete and our etiquette as strict as in the older professions. I ask members of this institution to keep before them, for their own sakes, as well as for the honor of the institution, an ideal of business or professional conduct at least as high as exists in the older and recognized professions of law and medicine, even although honorable behavior cannot, among us, be enforced by legal penalties or disqualifications.

A more subtle difficulty connected with the business side of our engineering life arises in the relations between the two great sections of engineering, which one may call the contractorial and the consultant. Each branch is honorable in itself—neither more than the other; many excellent engineers also have changed from one to the other for their own advantage, and to the advantage of engineering also. But now and then an attempt is made by honorable men, and in all honesty, to be contractors and consultants at the same time. Every such attempt, so far as I know, has ended in failure, and I am sure that the combination is to be deprecated. It may be a counsel of perfection, but I would go so far as to say that a consultant ought not even to hold shares in any manufacturing company with which there is the slightest chance that he may have to do in his professional capacity. There are plenty of things in which we can invest money without being in the least hampered by a self-denying ordinance of this extent.

It goes without saying that the relationship of engineering work to the industrial life of the country is of vast importance. Directly engineers are very large employers of labor; indirectly, through our railways and manufactures, we must be responsible for the employment of more "labor"—using the word in the popular sense—than any other set of men. Would it not be possible to take advantage of the present time, when the relations between employers and employed are, taken over the whole country, friendly and cordial, and when business generally is becoming more prosperous, to follow up the good beginnings which have already been made, and to take still more extended steps toward the establishment of joint trade committees, appointed specially to act when required as arbitration tribunals, under experienced leaders whose names would command universal confidence? Hitherto we have too often tried arbitration only when a fight was imminent, and when feelings were already strong on both sides, when each side had made up its mind vigorously, and when for either to give way meant some injury to *amour propre*. Surely that is a wrong way altogether. We know perfectly well that disputes will arise, and we know just as well that only in very exceptional cases is either of the two sides likely to be entirely right. At present the two sides say "can't" and "must" to each other until they are out of breath, and angry. How much better if machinery existed which had been created by both parties together, in which both had reason to trust, which could take up and settle the difficulties before the stage of mutual recrimination and vituperation had even commenced. There are times when the employers must put up with diminished profits—they have no divine right that everything should remain as it has been when it has been most satisfactory to them; there are times when the employed must put up with reduced wages—they have no divine right to have a permanent continuance of the wages they have earned when trade was at its very busiest.

What of the future of engineering? Is it possible to predict, or even to indicate with any approach to certainty, the lines on which the engineering work of our grandsons is likely to be carried out? I fear that it is not possible.

To a certain limited extent a traceable process of evolution does apply to both machinery and structures—with the latter only to a very limited extent indeed. It cannot be said, I suppose, that we can to-day make finer masonry structures—structures more perfect either from an artistic or a scientific point of view—than the Romans could, or the Greeks before them, or the Egyptians long before either. The only great developments in structural work have come about through the use of new materials and new methods for handling them. Concrete on the one hand—which in its present form may be considered new—and steel on the other hand, especially, have entirely altered our structural methods. As a species, steel structures may certainly be said to represent a "separate creation." The years taken to develop iron and steel-making machinery, and to develop the methods for using the material, are so few, historically, as to represent only an instant in terrestrial time. And before them the centuries went on one after another without bringing about the least indication of what was to happen in the fullness of time.

With machinery the same thing occurs, even in more marked fashion; one "species" after another starts suddenly into being, sometimes through the inventive talent of a single man, perhaps more often through the joint endeavors of many minds, directed to one special point by some requirement of practical industrial life. No doubt it might be suggested that the reaction wheel of Hero was a great grandfather of the present steam turbine; and I dare say it may be possible by diligent search to find—at least on paper—a somewhat discontinuous series of actual or possible machines connecting the one with the other over the interval of a couple of thousand years. But so little is there any real connection between them that up to a few years ago Hero's machine was always given in historical textbooks simply as a steam engine, and as the precursor of the present steam engine pure and simple, with no reference whatever to the special peculiarity—in fact, in spite of that peculiarity—that it was a turbine. Although no doubt the steam turbine of to-day is a development of and improvement on the steam turbine of twenty years ago, yet practically all this development and improvement has occurred at once, instantaneously, while nothing whatever occurred between B. C. 200 and about 1880. The steam turbine, in fact, was a new species, a "separate creation," and, as such, nothing connected with it or its possibilities could have been predicted on evolutionary lines beforehand.

It would appear as if "invention," whether in the popular acceptation of the word, or in the sense of painstaking working out directed to an object of immediate importance, constitutes such a disturbing influence in mechanical or engineering evolution that it is useless to attempt prophecy on evolutionary lines. It is, I am afraid, still more useless to try to forestall the future by trying to do to-day what one thinks may possibly be done by others ten or twenty years hence. Such attempts have been made several times, and much as we may admire the spirit of the attempt, we cannot, judging by results, admire its wisdom. The building of the "Great Eastern," whose history is a pathetic tragedy in engineering, which had to be broken up for scrap almost in sight of the "Carmania" and "Caronia," is a case in point which will occur to everyone.

But here again, unfortunately, "artificial selection" sometimes comes in, and plays havoc with the "laws." For although it may be pretty safely said that no invention becomes a great success that is not sound and useful essentially, it must also be admitted that every now and then an invention of distant utility disappears altogether—failing either through want of money or push on the part of its friends, or by too much money and push on the part of its rivals.

Another direction of development, especially in connection with mechanical affairs, is no doubt the increase of directness, the avoidance of transformation, and the decrease in the number of separate stages by which a required result is obtained. We burn coal, pass a part of the heat of combustion to water through metal which absorbs some of it, and utilize the balance for evaporation. We use a portion of the energy so gained by the steam in doing mechanical work, and a portion of this portion is transformed into electrical energy. But electrical energy as such is required for very few purposes, so that in general some percentage of the electrical energy is again turned into mechanical work, and even of this only a small part is actually useful—or it is turned into heat, of which a still smaller fraction appears as light, and is used as such. I read a paper on this subject before the Royal Institution some thirteen years ago, in which I pointed out that in the case of electric light much less than one per cent of the whole heat of combustion with which the process started appeared actually as the useful and salable commodity—light—at the end. Electric lamps are more economical now, but the proportion still remains ludicrously small.

It would seem natural to hope, therefore, in looking forward, that one of the chief directions in which the engineers of the future will carry out successful work will be that of increasing directness, avoiding transformation, and greatly increasing the efficiency of whatever transformation remains necessary. Engineers hardly need the warning, but the public certainly does, that so-called "improvements" in this direction, made without knowledge of what existing efficiencies are, or which embody physical impossibilities as soon as they are reduced to figures, are not schemes in which to invest money or promising real engineering development, to say nothing of commercial success.

WHAT AN EXTRA KNOT AND A HALF MEANS.

THE extra $1\frac{1}{2}$ knots that the big Cunard liners are to make over the "Kaiser Wilhelm II.," Germany's fastest ship, require the installation of 68 additional furnaces, six more boilers, over 52,000 additional square feet of heating surface and the development of an additional 30,000 horse-power. To provide for the increased weight the ship has to be lengthened $78\frac{1}{2}$ feet, broadened 16 feet, and deepened 4 feet, and the displacement enlarged by 12,000 tons. If turbines were not employed at least three 25,000 horse-power engines, with shaft and screw propeller, would have been necessary, and many difficulties would have had to be solved to place these so as to balance weights and to avoid vibration. With rotary engines substituted for reciprocating engines there are economies of space and other advantages.—Journal of Electricity, Power, and Gas.

THE DEVELOPMENT OF BATTLESHIP PROTECTION.*

It would be impracticable in a work of this character to attempt to discuss the development of warship design in our own or in any other country, nor is it desirable to do so. All that is required is to take one or more type ships and study the evolution and design with reference to armor protection as shown by these types, and then to compare the type ships as developed by the different countries with which we have to deal.

The "Oregon," one of the first battleships constructed after the development of the Harvey process, was laid down in May, 1891, and was completed in 1895. This ship has a very heavy water-line belt 18 inches in thickness extending along the machinery, magazine, and boiler spaces. At the ends of these are barbettes 17 inches thick rising on the center line above the main deck. The ends of the ship are unarmored. Barbettes protect the turret-turning gear and ammunition supply. Mounted over the barbettes are the turrets for the 13-inch guns, with 15 inches of armor at the sides and back, and 17-inch port plates. The casemate armor is 5 inches thick, but is of limited extent, and but poorly protects the two 6-inch guns. The quadrilateral 8-inch turrets have 8.5 inches of armor, the barbettes are 10 inches, and the ammunition tubes are 3 inches thick. The secondary battery is protected by 2-inch armor and thin gun shields. There is a conning-tower 10 inches thick, and a 7-inch communication tube. The armored deck is 3 inches thick, but flat on top of the belt, extending the length of the ship, sloping to bow and stern. There is also an armored bulkhead of 17 inches thick athwartships.

The "Royal Sovereign" and class were laid down in England about 1889-1891, and completed 1892-1895.

There were eight of the class built—seven with barbette mountings for the heavy guns, and one with turrets. The barbette ships were able to obtain a greater height of big guns above water than the turret ship ("Hood"), on account of the weight involved in the turrets. Although the Harvey process was being applied to the treatment of armor at the time, these ships were provided with compound armor.

THE INFLUENCE OF THE SLOPING DECK.

The above ships may be said to represent the type battleship of America and England, 1890 to 1895, and it is of interest to note that these ships are now being retired to the reserve.

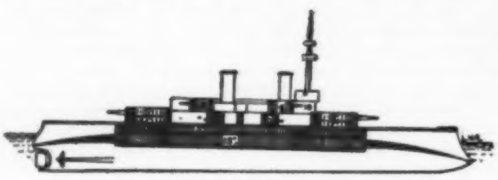
These ships were followed in the United States by the "Kearsarge" and "Kentucky," laid down in June, 1896, and completed in 1900, and in England by the "Majestic" class, laid down 1893-4-5-6, and completed 1893 to 1896.

"Kearsarge."—In this ship, when compared with the "Oregon," we find a slight decrease in thickness to 16 inches, and an extension of the water-line belt to the bow, tapering to 4 inches. In place of the quadrilateral 8-inch turrets, the 8-inch turrets were superimposed on the 13-inch turrets. The barbettes and turret armor were slightly decreased in thickness, and more importance given to casemate armor, 5.5 inches in thickness, which was made to cover the space between the barbettes. The belt is 7.5 feet wide by 290 feet long from the bow, the lower edge being 9.5 inches thick; upper belt (lower deck side) 190 feet long, with 2-inch screens in the battery. This ship may be described as a barbette-turret vessel, with superimposed 8-inch turrets, and a continuous or box battery of 5-inch guns inclosed in a central citadel or armored redoubt. It will be noted that the flat deck is retained. Displacement, 11,500 tons; weight of armor, 3,419 tons.

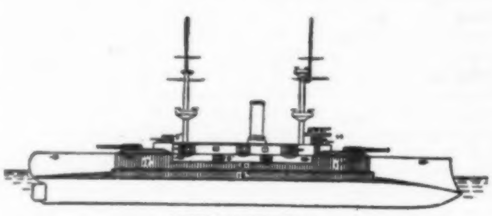
In the "Majestic" class we see a change to Harvey armor and to the inclined sides for the protective deck, and a corresponding decrease in belt armor. The belt is only 9 inches thick, but it is carried up to the main deck for a total depth of 15 feet. The length of the citadel is 250 feet, or about two-thirds the length of the ship.

The protective deck between barbettes was run level across at the middle line, but sloped down to the bottom of the armor at the side as shown in figure. This deck was 3 inches on the flat and 4 inches on the slopes. In this arrangement of armor the influence of the larger nature of quick-firing guns is seen. The protection at the water-line is not sufficient to keep out the heaviest projectiles. It is, however, backed up by the 4-inch deck (inclined), so that before the vitals of the ship are reached a penetration equivalent to about 30 inches of wrought iron is necessary. This does not equal the 33 inches of the "Royal Sovereign"; yet it is thought that a ship will be most difficult to hit at the water-line, and it was considered better to give up absolute protection at the water-line in order to obtain a larger area of good protection, and because of the development of the large quick-firing guns.

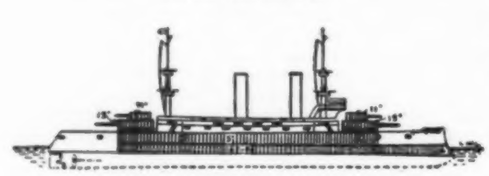
These ships were followed in the United States by the "Illinois" class. The principal features of the armor protection of these vessels were the abandonment of the 8-inch turrets, a more extensive use of casemate armor, which was made 5.5 inches thick to protect the 6-inch battery, the introduction of splinter bulkheads, and, what is more important, the adoption of the inclined port-plate for the 13-inch turret guns and inclined sides for the protective deck.



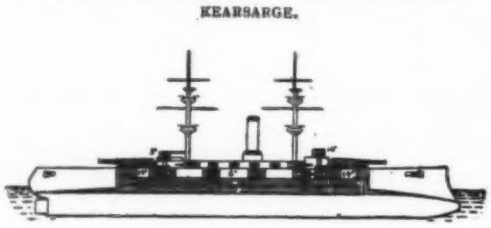
OREGON.



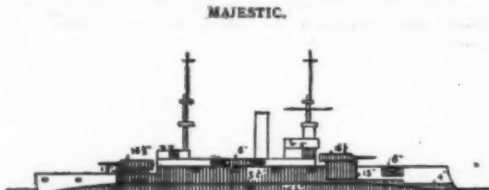
ROYAL SOVEREIGN.



KEARSARGE.

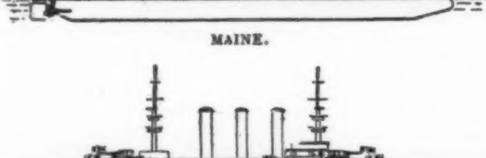


MAJESTIC.



ILLINOIS.

MAINE.



VIRGINIA.

KING EDWARD VII.

The "Maine" class followed. The general design of these vessels is similar to that of the "Illinois"; 6-inch armor was used for the casemates, and Krupp armor being at this time adopted, the armor protection was considered to be very superior to the "Illinois" class.

In the "Virginia" class, which followed, there was a return to the 8-inch turrets, two being superimposed on the 12-inch, and two being placed in broadside. The belt was made 11 inches, but carried all the way aft, tapering to 4 inches at the stern as well as at the bow. The casemate was extended still further, being carried forward and aft with athwartship bulkheads so as to include the 12-inch barbettes. The continuous battery of 6-inch guns is separated by splinter bulkheads inclosed in a central citadel which is divided longitudinally by an armored bulkhead in line with the keel.

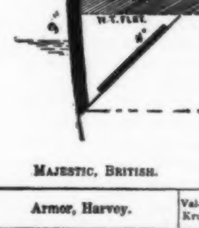
The "Louisiana" and "Kansas" classes, which followed, may be designated the same as the "Virginia," except that the 8-inch guns are mounted in turrets arranged quadrilaterally, and that splinter bulkheads inclose each of the 7-inch guns. In the "Louisiana" class we find a reduction in thickness to 11 inches in the water-line belt, which is further reduced to 9 inches in the "Kansas" class. In both classes we find the upper casemate armor is made 7 inches thick to protect the 7-inch guns.

The British retained the barbette-turrets for heavy guns and followed the isolated casemate system for the intermediate battery until the "King Edward" class was laid down in 1903. Beginning with the "Canopus," the belt armor of British ships extends to the ends, following the French practice, tapering from the barbettes.

In the "King Edward" class we find that the casemate system of protecting the intermediate battery has been abandoned, and a battery of 7 inches in thickness has been worked between the main and the upper decks to take the 6-inch guns.

The battery is covered in with 1-inch plating at the top, and this battery also performs the function of protecting the funnel casings, etc., to the upper deck. The armor belt is 9 inches at the water-line and 8 inches above to the main deck. This belt is carried in reduced thicknesses to the bow. The decks are as follows: Upper deck, over battery, 1 inch; main deck forward of the battery, 2 inches to 1.5 inch; protective deck, 1 inch on flats, 2 inches on slopes; lower deck, forward 1 inch, aft 2.5 inches.

Kearsarge, U. S. A.



Majestic, British.

Armor, Harvey, Nickel.	Val. in Krupp.	Armor, Harvey.	Val. in Krupp.
16.5-inch Belt, amidships	12-in.	9-inch Belt	6-in.
4-inch Belt, bow	3.5-in.	14-inch Bulkheads	9-in.
2.5-inch Deck, flat	2-in.	4-inch Deck, slopes	3-in.
Protection to vitals	14-in.	Protection to vitals	12-in.
10-inch Fore bulkhead	8-in.	14-inch Barbettes	9-in.
12-inch After bulkhead	9.5-in.	10-inch Turrets for above	7-in.
4-inch Deck, aft	3-in.	6-inch Casemates (12)	4-in.
15-inch Turrets	12-in.	14-inch Conning-tower	9.5-in.
15-inch Barbettes	12-in.		
5.25-inch Lower side	4-in.		
5.5-inch Battery	4-in.		
2-inch Battery, bulkheads	1-in.		
10-inch Conning-tower	8-in.		

The barbettes for the 12-inch guns have a maximum thickness of 12 inches, reductions being possible where battery would also have to be pierced before reaching the barbette. The shallow barbettes for the 9.2-inch guns are 4 inches thick.

Since the "King Edward VII." and class were designed, various causes have operated to produce a type ship which may be expressed in the design of the "Lord Nelson" class.

The French in all their designs have persistently adhered to certain peculiar features, namely: (1) a continuous water-line belt; (2) the use of turrets for the intermediate battery; (3) extension of the lower deck or casemate armor to the ends; and (4) the omission of all armor, except that for the ammunition tubes, etc., between the main and upper decks. The "Republique," which expresses this type, will be considered later.

German battleships have had no distinctive characteristics. As a rule, they are smaller and more heavily armed and armored than are contemporary vessels of the United States, Great Britain, or France. This is due to the necessity of keeping down the displacement on account of the German harbors. A peculiar feature is the use of ammunition tubes for the 6-inch casemates. This is necessary because the casemates are not, as in most casemate ships, built directly over the lower deck casemate armor, but are above an unarmored space. The "Deutschland," laid down in 1903, expresses the German type.

The early Italian battleships were remarkable for their big 100-ton guns. Their later designs have always been well thought out and adapted to the necessities of their fleet and harbors. Their latest type is a 20-knot battleship with a strong battery and fair armor protection. This is the "Vittorio Emanuele III." and class, and is a combination of the battleship and armored cruiser.

The Russians, it may be said, have in general followed French ideas, and in the same manner the Japanese have adopted the British designs, usually improving on them.

* Journal of the United States Artillery.

REINFORCED CONCRETE IN GREENHOUSE CONSTRUCTION.

By WILLIAM MCDONALD.

THE rediscovery of cement is quite recent, and while it has been used extensively in engineering and architectural work, both of which terms are fast becoming synonymous, yet cement in the form of concrete has only received its greatest impetus since the application of various forms of steel rods and expanded metal as reinforcing materials. This application is possible on account of the expansion of both materials being nearly equal, while the steel supplies the great tensile strength which the concrete lacks. It has been successfully applied to greenhouse construction, both in hollow concrete blocks and also in monolithic form. It is, however, the latter application which is here illustrated, as it is only in this way that the reinforcing can be applied. There is no doubt that the general application of concrete in the future will be in the monolithic form, for the reason above stated. The only objection in greenhouse work is the dampness, which keeps the houses cold in the winter; but this is obviated in a degree by using a damp course of coal tar ½ inch thick just above the level of the ground.

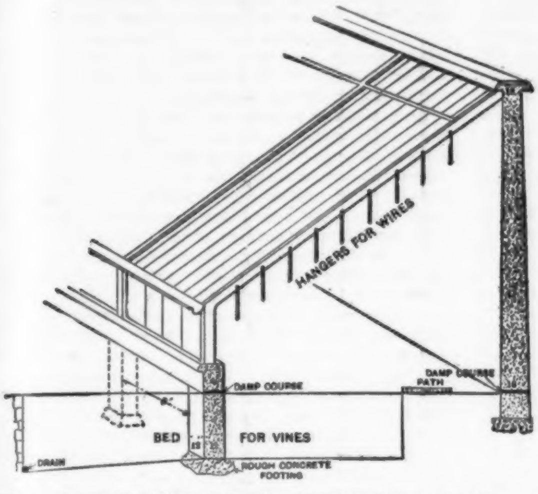


Fig. 1.—Isometric View Indicating Construction. Spacing for a Grapery.

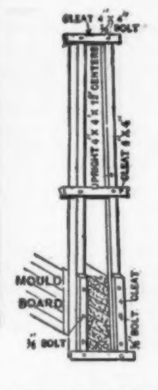


Fig. 2.—Cross Section of Mold, etc.

Fig. 3.—Elevation of Mold Board.

The best application of reinforced concrete is to graperies, the construction of which is indicated in Fig. 1 of the illustrations. These having to be supported on pillars so that there may be room for the roots of the vines both outside and inside, large spans are used as indicated in the engraving, these being represented 8 feet in the clear. The wall is 18 inches high and 12 inches thick, reinforced with 1 per cent of steel per volume, equal to eight ½-inch rods or four ¾-inch rods. The wall then really becomes a beam with 8 feet span. For the rear wall a section 18 inches wide at the bottom and 12 inches at the top is adopted with rough concrete footing. The molds for this are formed of 4 x 4-inch timbers placed 12 feet on centers and joined by cleats and bolts so as to give an accurate cross section of wall. These are to be braced as indicated in Fig. 2 until the first course of concrete is placed. The mold board, an elevation of which is shown in Fig. 3, is 4 x 12 feet, and constructed of ¾-inch boards planed on the inside and with cleats to bolt them to the uprights. Each time before they are used the molds should be oiled outside with dead oil.

The concrete should be composed of one part cement to two parts of clean, sharp sand and four of small broken stone. The mixing is very important, and as a general thing is not properly done. The sand for a batch should be spread evenly on the mixing board, and covered uniformly with the cement, after which they should be turned over twice while dry. The stone and the water should then be added, care being taken to wet the stones thoroughly; in fact, it is a good plan to wet them beforehand. The mixing is then completed and the concrete shoveled into the mold and lightly tamped.

For the tables indicated in Fig. 4 gravel is substituted for the broken stone, and the proportions are 1 part cement, 2 parts sand, and 3 parts gravel. In constructing the tables place a footing of concrete about 9 x 9 inches, and 9 inches deep under each iron pipe support, making sure that the pipe is firmly bedded in the concrete. It is also essential that the tops of the pipe supports be bedded in the concrete tables. Now place the mold in position with the supports under them as indicated in Fig. 5. As a table also forms a beam, the reinforcing rods are placed the length of the table, using for the purpose ½-inch square steel rods. The material is mixed as before and placed in position, a smooth skin being worked up on top of the table. The position of the mold for the rounded end is made to unscrew from the general mold. The upright rod imbedded in the concrete is all that is necessary for the support of the tables.

The above are simply examples of the application of this method of reinforced concrete construction, and the great advantage of it is that any small contractor with sufficient care can make a very satisfactory job. The same construction can also be applied to the walls and floor of the stoke hole to form pipe supports or for potting sheds, toolhouses, gardeners' cottages, etc.—Carpentry and Building.

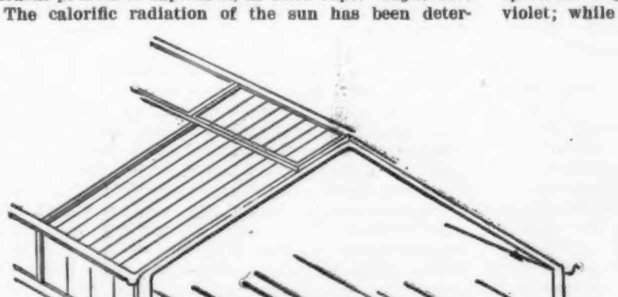


Fig. 4.—An Isometric View Showing Position of Tables, etc.

Fig. 5.—Cross Section of Mold Board for Tables.

REINFORCED CONCRETE IN GREENHOUSE CONSTRUCTION.

PROGRESS OF ASTRONOMY IN 1906.*

By E. WALTER MAUNDER.

THE SUN.—The state of the sun's surface during the year ending October 31, 1906, points to the sunspot maximum being already passed; a marked falling off in both the numbers and areas of sunspots having been noticed since the beginning of 1906. While 1905 was remarkable for the number of giant groups very easily visible to the naked eye, these have been rare during 1906, the most striking outburst being one that commenced on the visible hemisphere on July 27, and rapidly increased in size until by the end of the month it had attained an area of twelve hundred millionths of the sun's hemisphere. The tendency has been rather for spots of moderate size to form in long processions parallel to the solar equator; a very remarkable instance of such a procession was observed in November, 1905, and another not quite so pronounced in March, 1906. October, 1906, was a very quiet month; indeed the sun was then entirely free from spots on no fewer than seven days. A similar falling off has been remarked with respect to the faculæ, but it has been less pronounced than with the spots; the mean area of which for 1906 was about three-fourths of that for 1905. On the whole the maximum seems to have fallen about the end of 1905 for faculæ and prominences, while the maximum for spots should probably be placed at least six months earlier. Yet a caution must be observed in deciding thus soon as to the precise date of the turn of the cycle, for sunspots generally continue to be very active for fully four years at maximum during which they exhibit several strongly marked fluctuations, before the period of decline definitely sets in. It is therefore even yet somewhat premature to conclude that no further marked recrudescence of activity will be witnessed in the course of the present cycle.

A new determination of the stellar magnitude of the sun has been made by Prof. Ceraski, who employed the planet Venus as an intermediary for the comparison between the light of the sun, and of Polaris, Procyon, and Sirius; comparing Venus with the sun by day, and with the stars named by night. He found the sun's light one million times greater than Polaris × 290550; Procyon × 77630; or Sirius × 17045. The weighted mean of these three determinations gives the stellar magnitude of the sun as —26.59, or as Prof. Ceraski prefers to express it, as 26.59 *super magnitude*.

The calorific radiation of the sun has been determined afresh by MM. Millochau and Féry from observations made at three different levels; viz., Meudon altitude 150 meters, Chamonix, 1030 m., and Mt. Blanc, 4810 m. The maximum observed temperature at the last named station was 5590 deg. absolute; giving, when roughly corrected for the atmospheric absorption, 5610 deg. absolute, for the final result.

A research which promises important results has been initiated by Prof. Hansky at Pulkowa in the photographic registration of the forms and movements of the granulations of the solar surface. Prof. Hansky found that he was unable to recognize the forms of the granulations in successive photographs taken by M. Janssen at Meudon, but by taking photographs at intervals of from fifteen to thirty seconds on a scale of nearly two feet to the solar diameter it was found possible to trace the changes and movements to which the granulations were subject. After an interval of a minute, the same granulation was usually recognized with difficulty. The dimensions and rates of motion of the granulations varied within wide limits but their mean diameter was about 1.9 second, and mean speed about 21 kilometers per second.

The Sunspot Cycle.—The uncertainty as to our present position in the sunspot cycle, lends great interest to an attempt which Prof. A. Schuster has made to examine the precise nature of the sunspot periodicity. The method which he has employed in the analysis of the sunspot numbers of the last 150 years, is an application of Fourier's theorem, and he claims to have discovered in addition to the well-known cycle of 11.125 years, a number of minor periodicities, the integration of which in their varying intensities, produces the irregularities of the cycle actually observed. These minor periods are 4.78, 8.32, 9.25, 13.5, and 13.75 years; and Prof. Schuster points out the most strongly marked of these are, like the 11.125 period, simple sub-multiples of 33.375; while two-fifths of that period gives very nearly the value of the shorter 13-year period. The multiplicity of these periods, their near approach to commensurability, and the fact that they undergo suppression for considerable intervals of time, throw grave suspicion upon their reality, which it is to be hoped that the promised publication of the details of his investigation, will enable Prof. Schuster to remove. In the meantime, Prof. Schuster regards the relation of these periods to 33.375 years, which is nearly the revolution period of the Leonid Meteors, as a strong confirmation of his view that the secret of the sunspot variation is to be found in meteoric influence. Indeed in the Observatory for May, 1906, he claims to trace the "third of a century" cycle by means of Chinese sunspot observations as far back as A.D. 188, and draws attention to a coincidence, noted by Prof. Turner, namely, that the Leonids only entered the system in A.D. 126. He considers it possible that a meteoric stream might pick up some of the negative ions which had previously been projected outward by the sun, and if it did so, might at perihelion, supposing that it was then within a few solar diameters of the sun, affect the luminosity and shape of the corona, the variation of the spot phenomena following as a secondary effect of the coronal disturbance. The occasional disappearance of a period might be accounted for if it is supposed that radioactive matter is irregularly scattered through space, and that the meteor streams sometimes traverse a barren, and sometimes a rich region. It will be seen that in its present form, at any rate, Prof. Schuster's theory is confined to the mere suggestion of vague possibilities, hardly consistent with what we know of any meteor stream; certainly not with the Leonids which have their perihelion passage at about one hundred solar diameters from the sun.

Sunspot Spectra.—A number of valuable papers on this subject have appeared during the year, chiefly in the Astrophysical Journal. Besides the actual catalogues of "widened lines," and of "Maunder's bands" observed, the two chief questions debated are: "What is the cause of the darkness of sunspots?" and "Are sunspot spectra represented in stellar spectra?" On the first of these two questions Messrs. Hale and Adams do not accept Evershed's suggested defense of Maunder's view that the darkness of a sunspot is in part due to diminished radiation; for Evershed supposed that the maximum of intensity of the sunspot spectrum might be displaced into the extreme ultra-violet; while they found it was displaced to the infra-red. They also reject Fitzgerald's suggestion brought forward by Dr. W. E. Wilson, that the great convection currents which must exist within such a gaseous layer as that seen in a sunspot, would limit effective radiation to quite a shallow stratum. They therefore conclude "that the darkness of sunspots may be sufficiently well accounted for by absorption alone." Messrs. Hale and Adams are also quite unable to support Lockyer's view that at the period of sunspot maximum the lines due to known elements are replaced by

* Popular Astronomy.

unknown lines. Their observations showed that but a little more than a quarter of widened lines were "unknown," and many of these were of extreme faintness, while more than one-sixth of the lines were due to iron. Nor do their results support Fowler's conclusion that lines in the spot are strengthened in proportion to their intensities in the sun in the case of elements like titanium represented by comparatively faint lines.

The other question under discussion has also produced a difference of opinion. Dr. W. M. Mitchell failed to find much correspondence between the spectra of sunspots and those of the fourth type stars. Hale and Adams on the other hand found the typical sunspot lines strongly affected in the spectra of Arcturus and of Alpha Orionis (second and third type stars), the lines being least affected in the sun and most affected in Alpha Orionis, suggesting that the temperature of the last named star is the lowest.

Cloud Spheres and Photospheres.—These discussions may receive illumination from a suggestive paper by Mr. A. W. Clayden, read before the Royal Astronomical Society. In this he points out that the result of suitably diminishing the mass of a planet may be to produce exactly the same effect upon any cloud-sphere by which it is surrounded, as would be brought about by increasing its temperature. A hot planet of large mass might present exactly the same features as a cooler and smaller one, and a determination of the temperature of the outer surface of the cloud sphere would be no measure whatever of the temperature of the solid planet beneath. A strictly analogous result holds good in the case of the photospheres of stars. The determination of the temperature of a photosphere is no guide to the temperature of the star center. Neither is the position of the photosphere much help. If the ratio of temperature to pressure in two stars be identical, their spectra will be identical, so that a large hot star may show exactly the same spectrum as a smaller and cooler one.

The Moon.—The publication of the Ninth part of the great Photographic Atlas of the Moon by MM. Loewy and Puiseux, has given the authors an opportunity for discussing several theories with respect to the lunar surfacing. The seas and craters of the moon cannot have been caused by swarms of meteors circulating round the sun, and encountering the earth and its satellite, nor by the ejecta from terrestrial volcanoes, nor by the capture of a primitive satellite ring once revolving round the earth. But their studies have convinced MM. Loewy and Puiseux, as their chief predecessors in this field have been convinced, that the preponderating part in the formation of the lunar seas and craters must be assigned to volcanic forces acting from within the moon itself, and not to any external origin. In the British Astronomical Association Journal, Mr. H. G. Tomkins has argued that the brightness of the radiating streaks is due to saltpeter and other saline products working upward to the surface, adducing a phenomenon of the kind which he has not observed in the Punjab. Prof. W. H. Pickering doubts whether the phenomenon observed by Mr. Tomkins is more than a local effect, as he has not observed it on the salt prairies in the Western States.

Mars.—During the past year, the only observer of Mars who has published his observations has been Mr. Percival Lowell of Flagstaff, Arizona. In the Monthly Notices for December, 1905, he gives as the most probable position of the pole of the Martian equator: R. A. 317.5 deg., and declination 54.5 deg., epoch 1905. Tilt of Martian equator to Martian ecliptic, 23 deg. 59 min. This value has been adopted in the Nautical Almanac beginning with the volume for 1909. Mr. Lowell has also issued in a fine volume, his observations of Mars during the oppositions of 1894, 1896, 1898, 1901, and 1903. These oppositions were all previous to Mr. Lowell's successful photography of the canals of Mars, and the work has naturally fallen into two great divisions: the polar caps, and the surface outside them. Mr. Lowell points out that the details of one Martian year are not the exact counterpart of those of another, except in the one respect of position. If a canal or spot is seen, it is seen *in situ*, but it may not be seen at all. In the opposition of 1896, he drew attention to the important fact that the Gihon and Hiddekel were detected as doubles, important in that one of each pair left its own bay of the Sabaeus Sinus, and as the two bays of the Sabaeus Sinus have been universally accepted as facts, this at once negatives the conclusion that the doubling, in these cases at least, was optical. In the opposition of 1900, he remarks that the duplex canals surrounded the oases which they passed, one component passing round the oases on one side, and the second component on the other; the oases themselves were not doubled as they should have been, were the phenomenon merely diploptic.

The Asteroids.—Mr. Joel Metcalf in the Astrophysical Journal for May, proposes a novel method for the photographic discovery of asteroids. The method of Prof. Max Wolf is to take a long-exposure photograph of the region to be examined, and then search the plate for trails made by the moving planets. As the asteroids, when in opposition, move on an average 34 sec. per hour, it is possible that they may be too faint to produce any impression on the plate. Now objects of any degree of faintness can be photographed if the exposure be sufficiently prolonged, and Mr. Metcalf proposes to give the photograph a motion of about 34 sec. an hour in a given direction, thus following an asteroid with a considerable degree of accuracy. The small planets would present disks that are nearly round, while the brighter stars would give short trails. In the July number of the Astrophysical Journal, Dr. H. N. Russell gives the results in an investigation on the light variations of asteroids and satellites. He concludes if a variable asteroid has been observed at a series of oppositions in all parts of its orbit, that we can determine whether its light curves can be accounted for by rotation alone, and if so whether the asteroid (*a*) has an absorbing atmosphere, (*b*) is not of a convex form, or (*c*) has a spotted surface. He also shows that it is not possible to determine the shape of an asteroid; if any continuous convex curve is possible, all such forms are possible.

The Minor Planet TG.—Three new minor planets were discovered by Dr. Max Wolf on a photograph taken on February 22. Two of these were remarkable for their rates of retrogradation; TF moving unusually quickly, and therefore being of small mean distance, TG moving very slowly and so being of great mean distance. The latter planet has, on further observation, proved of extreme interest. Eros, discovered eight years ago, is the nearest of all the asteroids, coming at its perihelion well inside the orbit of Mars; its distance being only 1.1 units. TG, on the contrary, is the most remote, and breaks the bounds usually assigned to the asteroid family on the other side, for at aphelion it passes beyond the orbit of Jupiter. Nor is this all. Not only are its mean distance and its period almost precisely the same as those of Jupiter, but its distance in longitude from Jupiter is nearly 60 deg., so that the sun, Jupiter, and TG very nearly occupy the points of an equilateral triangle. Lagrange had shown that this was a possible case of the Problem of Three Bodies, and Dr. Charlier has further proved that the system might be stable even if the triangle were not accurately equilateral to start with.

Jupiter.—Major Molesworth has published his observations of Jupiter for the year 1904-5 in the January number of the Monthly Notices. When his observations ended in June, the great south tropical dark area was practically in conjunction with the Red Spot bay. In the passage of this dark area by the Red Spot, the same phenomenon seems to have occurred as in 1902, June, namely as the preceding end of the area reached the following shoulder, a dark wisp formed across the south tropical zone at the preceding shoulder, and moved down the zone at the normal speed of the dark area. As soon as the following end reached the following shoulder, the dark area became complete on the other side of the bay, and moved off at its normal speed down the zone. The dark area seems to have passed neither over nor under the bay but round it by way of the South Tropical Belt, completely skirting the oval of the bay without encroaching on it in any way. The dark area has a peculiar effect on the rotation period of the dark "wave crests" in the south edge of the South Equatorial Belt, and the intervening white spots. Before the formation of the dark area these markings had a period practically identical with that of the Red Spot; but since the formation of it, in May, 1901, their period has been very variable, retarded as it approached them, accelerated after its passage and returning to their normal rate with increasing distance from it. The great South Dark Area has had an effect on the rotation period of the Red Spot itself. Mr. Denning shows in the Observatory for September that from March 24 to May 4, the Great Red Spot and the Hollow in the South Equatorial Belt moved as nearly conformably as possible to Ephemerides based on a rotation period of 9d. 55m. 40.6s., but in June the Dark Area was in conjunction with the Red Spot, and in the following three months the spot lost 16 deg. or 26m. 29s. relatively to the zero meridian, the rotation being 9d. 55m. 33.8s., a much more rapid rotation than has been previously observed.

Jupiter's VIth and VIIth Satellites.—The two small new satellites of Jupiter have been observed, not only where they were discovered at the Observatory on Mt. Hamilton, but they have also been photographed at Greenwich. At the latter place, images were secured with the record short exposure of seventeen minutes. Dr. F. S. Ross has published a new orbit of Jupiter VII, giving it a period of 259 days, which is eight days longer than that of VI. But the orbits of the two satellites have very similar eccentricities, inclinations and periods, so that no less than twenty-two years are required for VI to gain one revolution on VII. Mr. Crommelin considers that this indicates a common origin for the two bodies.

Phoebe and Planetary Inversion.—Last year Prof. Pickering threw out the suggestion that the rotation of Saturn was originally retrograde, and that solar tides reversed the sense of its motion after Phoebe was produced, but before the production of the inner planets. Mr. T. F. M. Stratton has treated this suggestion mathematically, and concludes that not only Phoebe, but also Japetus and Hyperion were shed while Saturn's obliquity was over 90 deg., but that the two larger satellites moved over with the planet's equator while Phoebe sank down to the ecliptic in a retrograde orbit. Uranus experienced feebler solar tides, and its satellites were evolved at an earlier stage than the large inner satellites of Saturn; the Uranian satellites have therefore stopped the decrease in obliquity arising from the solar action and are now driving Uranus back to the stable position with an obliquity of 180 deg. Neptune's one satellite has a large tidal influence and is driving its primary back also to equilibrium position with an obliquity of 180 deg. Mr. Stratton's work does not, however, give any explanation of the anomalous orbits of Jupiter's two outermost satellites.

The Stars.—In the Monthly Notices for January, 1906, Prof. E. E. Barnard discusses the question of the proper motion and parallax of the Ring Nebula in Lyra. His measures of the central star of the nebula and of a twelfth magnitude star, *a*, following it, made in 1898 and 1899, differed consistently from those made by Prof. Burnham in 1891, the distance between the two stars apparently being diminished. In 1902, Dr. Newkirk investigated the proper motion and parallax of the nebula and found that its parallax was 0.10 sec., its annual motion being 0.180 sec., along position angle 303.7 deg., its motion tending to increase the distance of the nebula from the star *a* by 0.75 sec. In the five years since Prof. Barnard has taken a series of measures in 1903-4-5 to verify Dr. Newkirk's results but fails to find any measurable change in the position of the nucleus or central star. He is driven to conclude that Dr. Newkirk's proper motion is not verified, and that therefore the parallax of the nebula which depends on it, is not real.

In a valuable investigation on the dimensions of an Algol variable, in the same number of the Monthly Notices, Dr. A. W. Roberts finds that the distance between the component stars of U Pegasi is about 63,240,000 miles, and of RR Centauri, 3,800,000 miles, the orbit of this last star being practically circular.

In the February number of the Observatory, Dr. Roberts also discusses the interesting case presented by the increasing period of the variable star Beta Lyræ. Here there is no certain evidence of a closed cycle of orbital changes; the period of the system is apparently a constantly increasing quantity, though it increases by a diminishing rate. Notwithstanding this it is not probable that the variation is secular in character. Were it so, there must be a vast central controlling body, and an orbit which Beta Lyræ would take five centuries to traverse. But Dr. Roberts considers that the true reason is the slow recession of the component stars from one another; a very slight recession of one thousandth part of the radius of the orbit would account for the augmentation in time, 30m. in a century. That the great tides which must act as a drag on the rotation period of the close binary, should in a century increase the distance of the components from 1.00061 to 1.00180 is not remarkable. Comparison of the light curves at intervals of fifty years seems to indicate change in the size and shape of the orbit, and there is also some evidence that the eccentricity is increasing.

Mr. Heber D. Curtis has contributed to the Astrophysical Journal for June a most valuable discussion of the system of Castor. He says that in Castor we have two systems whose orbital dimensions are probably of the same order of magnitude. The brighter component has, however, the very great eccentricity of 1.50, while the fainter pair revolve in orbits which are practically circular. This extraordinary difference seems to indicate that the brighter component is the older, and that the fainter is spectroscopically speaking, a binary of relatively recent origin. The mass of the fainter component should be about six times that of the brighter one.

It has been generally assumed among astronomers that at least a few stars are of extraordinary intrinsic brilliancy; Gill for instance gives the luminosity of Canopus as 20,000 times that of the sun; and Kapteyn in No. 11 of the Groningen Publications says: "There will be a space which contains 2,000,000 stars of the same luminosity as that of the sun, one star with 100,000 times greater luminosity," thirty-eight stars with 10,000 times greater luminosity, 1,800 stars with 1,000, etc., together with more than 12,000,000 stars of smaller luminosity than the sun. In the Astrophysical Journal for April, Mr. G. C. Comstock gives reasons for concluding that there is no adequate evidence that the maximum of stellar luminosity requires more than three figures for its expression; nor that the mean luminosity of the first magnitude stars can be represented by a number with less than three significant figures. He considers that the erroneously great values assigned to the luminosity of certain stars is the result of a transition from relative to absolute parallaxes. A few parallaxes have been left decidedly too small and have produced correspondingly great values of luminosity.

Prof. E. E. Barnard draws some important conclusions from his photograph of the great photographic nebula which he obtained round Pi Scorpii. All the larger stars connected with the nebula, whose spectra have been observed, are of the Orion type. The Orion stars, according to Prof. Frost, are probably in a primitive condition, and are also associated with nebulosities, while the converse seems to hold for stars of the more advanced types of spectra. Prof. Barnard continues: "Such nebulæ as this one, and others of similar branching, straggling appearance, rather tend to make one doubt the generally accepted form of the nebular theory. Indeed this theory seems to have been built mainly upon the visual appearance of the nebulæ when seen in very inferior telescopes. It seems to me doubtful if the nebular theory would have been constructed at all if at the time our present knowledge of the appearance of the nebulæ, as shown by photography, had been available. It has always seemed to me that the nebular theory accounts for the existence of the stars in a very strained manner, and that it has very little to commend it.

"While there are some of the nebulæ (I do not speak now of the spiral nebulæ) that seem to agree in appearance with the theory, there is a much larger percentage that seem to be directly opposed to it. It does not appear necessary that the association of a star and a nebula proves that the star was formed from the nebula."

The Planetesimal Theory.—A new cosmical hypothesis has been propounded during the past year by Messrs. Chamberlin and Salisbury. Instead of the extended and tenuous nebula of Laplace, or the sparse meteoric swarm of Lockyer, they hypothecate a cen-

tral heliod with knots of denser aggregation which become the nuclei of the several planets. The constituents of the system might be molecules or small masses of any kind, moving in orbits about a common center, the essential point being that their behavior depends on revolution in independent orbits.

Double Stars.—The most important event of the year in this department has been the publication by the Royal Astronomical Society of a great memoir by Mr. T. Lewis on the stars of W. Struve's Mensuræ Micrometricæ. This noble volume not only exhibits the complete observations made of over 3,000 pairs from the date of the discovery of each down to the present time, but orbits have been computed wherever possible, and the orbits deduced by other computers have been critically discussed, and if necessary, corrected. Two of the orbits thus discussed are of peculiar interest; Delta Equulei, the period of which used to be taken as 11.4 years, but which Prof. Hussey showed to be really half that length, Mr. Lewis's discussion confirming the shorter period; and 61 Cygni, where the motion of the companion appeared uniform and rectilinear so long that some regarded the pair as merely an optical double. Mr. Lewis shows that there is now clear evidence for orbital motion, with a persistent wave of about ten and a half years' period. This wave is probably due to an obscure companion, and is quite a different one from that which Dr. Wilsing thought he had discovered from measures of photographs, with a period of twenty-two months and an amplitude of 0.3 sec. Prof. Barnard has, however, observed the pair for more than four years, and has failed to find any evidence of the oscillation reported by Dr. Wilsing. A further point of interest in Mr. Lewis's memoir is that by an ingenious use of the proportion existing in different parts of the sky, between pairs relatively fixed and pairs in orbital motion, he has been able to make an important contribution to the problem of the form of the general sidereal system, and has shown that the sun is eccentrically placed within an egg-shaped cluster of stars.

While by combining the known proper motions of stars with their orbital motions, he has shown that in twelve cases out of the eighteen examined, the fainter star is really the more massive, and in three cases more the masses are equal. In only three cases out of eighteen, is the brighter star really the more massive, and even in these cases the disparity in mass is much less than in brightness. Further, in most of these pairs the fainter star is of a more bluish tint than the brighter, and is therefore supposed to be of the Sirian type of spectrum; a type hitherto supposed to be characteristic of stars of low density; not of very massive stars as seems to be the case. Evidently this may require ere long a reconstruction of some of our ideas of stellar physics.

The Systematic Motion of the Stars.—In a paper read before the Royal Astronomical Society at its November meeting, Mr. A. S. Eddington discussed the Greenwich-Groombridge and Greenwich-Carrington proper motions with relation to Kapteyn's hypothesis of two star-drifts, and on the truth of this hypothesis arrived at the results that (1) The numbers of the stars belonging to the two drifts are nearly equal. (2) One drift is moving relatively to the sun, with a speed between three and four times that of the other. (3) The proportion of stars belonging to each drift is about the same in every part of the sky and at every distance here dealt with. (4) The magnitudes of the stars belonging to the two drifts are about the same. (5) The spectral types of the stars seem to differ to some extent in the two drifts but the evidence is not conclusive. (6) These results apply to all stars down to magnitude 9.5.

Danger to Greenwich Observatory.—One event of the past year, though in itself not strictly astronomical, cannot be passed unnoticed in a summary of astronomical matters—the threatened danger to Greenwich Observatory. The London County Council have been erecting a huge electrical generating station to contain eight engines working up to 52,000 horse-power about a half mile north of the Observatory, and exactly on the meridian. Even now, when no more than 3,000 horse-power is developed, the vibration sensibly affects observation with the transit-circles, and the four huge chimneys come almost into their fields of view. This danger to the efficiency of Greenwich is of course in the first place a concern to British astronomers, but is not confined to them alone, for not only is science not a question of nationality, but in more than one respect Greenwich possesses a distinct international importance. Its meridian has been adopted as the prime meridian of the world by nearly all civilized nations, and the fundamental observations of the moon's place have been practically committed to it by the general consent of the astronomical world. These and similar considerations, therefore, moved the Astronomische Gesellschaft at their recent session, held in Jena, to pass a strongly worded resolution regretting the danger to which the Observatory was exposed.

The tendency of the times now is directed away from the cosmic and toward the ethical method of management in industrial and commercial affairs. We are beginning to realize that no success counts which is obtained at the expense of others. That no triumph is a real one which is attained by pulling others down or by keeping them down. In fact, that no life is worth very much which does not consider the welfare of others. The United States government for the first time at any industrial exposition exhibited at St. Louis last year a large number of photographs and pamphlets descriptive of methods of industrial betterment adopted by leading manufacturing concerns in this country, thus showing the present trend of thought in this direction. The United States Bureau of Labor in its report for 1904 dwells especially on the increase in the number of concerns which have taken this advanced stand. Teachers of political economy in colleges, leading clergymen, lawyers, statesmen everywhere are advocating the adoption of ethical principles in business dealings. President Roosevelt voices this sentiment in his advocacy of giving the other fellow "the square deal," which after all is only a modern way of expressing the Golden Rule which political and social economists all say is the most practical rule of life ever enunciated.

SCIENCE NOTES.

A description of experiments with a rotating liquid sphere tried by P. Thirion appeared in the Annal. Soc. Sci. de Bruxelles. A spherical glass vessel containing water in which solid particles are suspended, being caused to rotate, the particles collect in a complicated manner. A fairly sharp circle of particles forms in the lower hemisphere, while in the upper a cloudy appearance is produced. By carefully adjusting the conditions of experiment a definite circle may be produced in the upper hemisphere, which is nearer the equator than that in the lower, and which appears to be very unstable. From the equation for the forces on any particle it is found that the lines of force only cut the surface of the sphere at right angles in one region, and that is the circle in the lower hemisphere. Hence this is the only locality at which the particles which are denser than water can remain in equilibrium. If, however, there is friction between the particles and the sphere the region of stable equilibrium is widened, and one appears in the upper hemisphere. By roughening the sphere inside, the author found it to be quite easy to produce the upper circle.

In the course of an expedition made by Mr. Claude White, the British political agent at Sikkim, into the territory of Bhutan, he was successful in obtaining a live specimen of the rare animal the takin. The journey was undertaken on behalf of the British government for the purposes of investing the Tongsa Penlop, the ruler of Bhutan, with a distinguished order in recognition of the services he extended to the authorities on the occasion of the British military expedition to Lhassa. The ruler himself came to meet Mr. White, undertaking a ten days' journey from his seat at Biaga in order to meet the former at Lhakhang. The party then set out for the Lhalong monastery, which is one of the most famous establishments of this kind in Bhutan, the chief incarnate Llama being a nephew of the Bhutan sovereign. Here a festival was inaugurated in honor of the official's visit, comprising one of the remarkable Llama dances, a fearsome orgy in which the participating dancers conceal their heads in animals' heads of grotesque design. In the course of his journey the official proceeded beyond the confines of Bhutan and explored a large portion of Tibet which has never previously been visited by white men, and in the course of his travels he secured a specimen of the strange animal takin (*Budocas axicolor*) which is rapidly becoming extinct and which has never before been seen alive, or shot, by any but the natives. A very fine specimen of the animal was presented to Mr. White, but during his return to Sikkim the animal died in the Chumbi valley. The natural haunts of this beast, which resembles in its appearance half ox and half antelope, is just below the snow line, and it was stated by the natives that it is only to be found in three places in the Bhutan country.

In an extract of a paper read before the Böhm Kaiser Franz-Josef-Akd. d. Wiss. in Prag. and which later appeared in the Phys. Zeitschrift, B. Kucera and B. Masek determine the absorption of polonium ("radiotellurium") rays in their metallic films. The absorption of the α-rays from polonium in metals and gases is indicated by the reduction of the ionization curve to a lower level, as in the case of the α-rays from radium and its products. The atomic absorption or stopping power is approximately proportional to the square root of the atomic weight and has nearly the same value as in radium C. In a given gas the ranges corresponding to the same velocities of α-rays are proportional to the densities. In different gases, such as air, oxygen, and CO_2, the ranges corresponding to the same α-ray velocities are exactly inversely proportional to the mean square root of the atomic weights. An important result is that the absorption of the α-rays changes with their speed, and is probably proportional to it. The atomic absorption increases with increasing speed, instead of decreasing as alleged. The dependence of atomic absorption upon the mean square root of the atomic weight is the same in metal and gases, and is not affected by the state of aggregation. The authors further attempted to confirm the existence of a secondary radiation produced by the impact of α-rays upon a metallic surface or by their passage through it. The lateral opening of an electroscope was covered with wire gauze and a vertical plate covered with polonium was placed in front of the gauze at such an angle that no α-rays could penetrate directly into the electroscope. Then a vertical lead plate was placed 1.5 centimeter from the preparation in such a manner that the secondary radiation and reflected α-rays would penetrate without difficulty into the electroscope, after traversing 1 to 3 centimeters of air. Any secondary or reflected radiation amounting to 0.05 per cent of the original radiation would have been indicated, but the electroscope showed no effect whatever. The effect actually produced upon the α-rays by a metallic screen is a diffusion, like that of light in a fog. The scattering effect of metals increases with their atomic weight, probably in proportion to the square root of it. If there is an expulsion of electrons by the plate, these must be of the slow kind first discovered by J. J. Thomson and Rutherford.

ELECTRICAL NOTES.

The paper on Heusler's magnetic alloys by K. E. Guthe and L. W. Austin, published in the Bureau of Standards Bull., treats of the measurements of the magnetic properties of a series of specimens of these alloys together with measurements of the magnetic field on the thermo-electric properties. Attempts were also made to measure the mechanical properties (Young's modulus) of the alloys, but all the specimens behaved very erratically and several broke at low loads on account of internal flaws, so that the authors are unable to say more than that Young's modulus is high. Chemical analyses and magnetization and magnetostriction curves are given for all the alloys tested, no thermal treatment having been employed. The magnetostriction is found to increase more rapidly than the magnetization, and no contraction is found even for strong fields. No change in the thermo-e.m.f. could be observed in these alloys even when the specimens were strongly magnetized; and since Kerr's phenomenon is also believed not to occur, the authors conclude that certain properties associated with ordinary magnetic materials are absent in these alloys.

In the year 1890, Hatch, of Boston, Mass., made storage batteries. He used grooved earthenware separators and filled his negative and positive active material into either side of the separators themselves. The current was drawn off by conductors of plain sheet lead, which were placed between the separators. The whole was placed together, so that absolutely no space at all was allowed for the electrolyte. It was the failure to recognize the necessity for the diffusion of the electrolyte, or at any rate, means for supplying the active matter with sufficient electrolyte close at hand to do its work, which was fatal to the Hatch cell. So long as only a very small current was required from the cell, it was fairly efficient, but if any real work were attempted, if it were put on at, say, a two-hour rate, the voltage immediately dropped to an unworkable figure. It is, however, a remarkable fact that if Hatch, instead of filling up the whole of the space with active material, had merely coated the porcelain slabs with a film of active material, he would have fulfilled all the conditions which are called for to-day in the solid network type of cell.

The magnetic variations in iron under torsion are described by F. Piola and L. Tieri in Acca. Lincei Atti as follows: Given a disymmetrical cycle composed of an arc of a symmetrical cycle and an arc of return, interior to the same, the limiting line of the interior arc is within the area inclosed by the limiting lines of the symmetrical cycle. In every internal arc there is a point which, after an infinite number of cycles of torsion, corresponds to an intensity of magnetization equal to the initial; and this neutral point is on the corresponding limiting line, and is therefore within the area inclosed by the limiting lines of the symmetrical cycle. To the various points of the internal arc corresponds an irreversible effect, which consists in an increase of the magnetization or a diminution, according as these points are on one side or the other of the neutral point. When the internal arc indicates, in the direction in which it is traversed, a diminution of magnetization, the points of that arc comprised between the limiting lines of the symmetrical cycle undergo during the first elastic cycle a variation in the magnetization opposed to that which they undergo in succeeding cycles.

Washington is not to have the immediate benefit of the electrification of all the railroads entering the new union station in that city, after all, it seems. A correspondent in the capital, noting a recent statement to that effect in the Western Electrician, states that a short time ago the commissioners of the District of Columbia sent a request to the railroads entering the city, asking if they would take this step in the near future, but this has met with a flat denial on the part of all the roads, as the claim is made by the railroads that the use of such motors is at present in an experimental stage only, and, further, that it would defeat the object so much in view at the present time, that of rapid transit between Washington and the outside world. They claim there would be much waste of time consequent on such change of motive force. This being the case, it is the intention of the commissioners, especially Commissioner MacFarland, who has the matter very much at heart, to try and bring the matter up before the present session of Congress, and see if by some means the railroads entering the city can be compelled by law to do what they have already refused to do voluntarily. It is to be hoped that Congress will meet the appeal of the commissioners in a sympathetic spirit.

Two rival views have hitherto been held with regard to permanent magnets. According to one, such a magnet is the seat of a constant number of lines, so that while changes in the reluctance of the magnetic circuit (such as those due to the approach or withdrawal of an armature) produce changes in the distribution of the flux, the total flux remains unaltered. According to the other view, the total flux undergoes changes, but the magnet behaves as if it were the seat of a constant magnetomotive force. To decide between these two theories, E. Kempken undertook the following experimental researches, which appeared in Ann. d. Physik. 20. A split anchor-ring of

magnetized steel was used, the two halves of which were mounted in such a manner as to allow of their being separated by an accurately measured distance, and measurements were made of the flux across the air-gaps and changes of the total flux by the aid of suitable exploring coils connected to a ballistic galvanometer. The results may be summarized as follows: (1) If the reluctance of the magnetic circuit of a permanent magnet be varied so as to produce changes in the air-gap field not exceeding 170 per cent., the magneto-motive force may be regarded as having a constant value (the variation being less than 1 per cent). (2) It is probable that the magnetomotive force remains sensibly constant for even larger changes in the reluctance. (3) During the changes of air-gap field due to changes in the reluctance, a small amount of hysteresis is observed. (4) The magnetic flux of a permanent magnet does not remain constant during changes of reluctance.

ENGINEERING NOTES.

Since the majority of failures of gas power plants have been due to the fact that the engines selected were too small for the maximum duty which they were expected to perform, the rating of gas engines should be standardized, and the public should be advised by the manufacturers that for a service with heavy overloads, such as occur, for instance, when driving rolling mills, the capacity of gas engines must be considerably larger than that of steam engines. Though the ideal is still far from what we have actually attained, it would be wrong to conclude that the present type of gas prime movers is not on a high level of excellence, not only as an economical, but as a reliable machine. Just as the steam turbine cannot be regarded as having reached its highest state of perfection and yet is a commercial engine of the greatest possibilities, so it is with the gas engine. After having passed out of the costly experimental state and after having reached a condition of standard design, its manufacture is now as profitable to the engine builder as its application is to the power consumer.

Regarding the latest thermal performances of internal combustion engines, Junge, in a paper read before the American Society of Mechanical Engineers, called attention to (1) a 14-horse-power Marienfelde alcohol motor and a 70-horse-power Diesel oil engine, showing on test an indicated thermal efficiency of 41.7 per cent; (2) a 20-horse-power Gueldner gas engine running on city gas with 42.7 per cent, and (3) a 500-horse-power Borsig Dechelhauser coke oven gas engine with 38.6 per cent. These figures refer to approximately full load conditions. Therefore, one horse-power indicated in the cylinder of the best gas engines so far on the market requires the expenditure of only 1,490 calories or 5,900 B.T.U. The economic efficiency of the latest types of gas engines, based on the actual output of available work is, therefore, between the limits of 32 and 33 per cent. With the rapid spreading of industries at this time, the wisdom is urged of designing power plants with a view to prospective rather than to immediate earnings. Therefore, comparisons of the cost of different types of plants are not only for the most part inaccurate, but are also of local and momentary value. Earning capacities depend on the market for the output. Markets commend the employment of the most economic methods of fuel transformation, utilization, and conservation, rather than the adoption of methods which appear to secure the maximum immediate profit. The question of the economic relation of a gas to a steam plant has passed into an entirely new phase since it became possible to directly gasify such fuels as cannot be efficiently used for raising steam under boilers.

There are at least two outstanding fundamental factors in the economics of the design of civil engineering work: there is the necessity for economy in the first cost from the point of view of the minimum charge of interest on capital expended, and there is the necessity for prudence from the point of view of sufficiency coupled with the cost of maintenance. We would have young civil engineers specially remember that in the selection and approval of materials it is essential that there shall be exercise of such sound judgment as will have the certain effect of securing durable work—that is, work that will not be unduly affected by the ravages of time and tear and wear and decay. The unfortunate necessity of having continually to spend money in repair and renewal must be constantly borne in mind, and the civil engineer does not do his duty if in scheming, designing, and constructing work he fails to realize and constantly remember that things wear out, and that it is essential that he should insure that in all reasonable time there shall be the least possible expenditure in maintenance. It is the absolute duty of the civil engineer to devote himself to consideration of the means by which the everlasting burden of perpetual expenditure in maintenance may be minimized, and he must have great regard to practicability, and so design and construct work that its upkeep and renewal may be readily accomplished with the least possible inconvenience and the least possible cost. It is, of course, impossible so to design and construct works that there will be no need for any expenditure in maintenance and renewal; but by the exercise of reasonable discretion in the design, care in the selection of materials, and thoroughness in execution, it is possible to insure that expenditure being at the minimum.

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